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SANFORD R. COWAN, Publisher

October 1960 **Vol. 3 No. 1**

CONTENTS

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Front Cover

Parametric mode transistor operating at ultra-high and microwave frequency ranges has been developed by Hughes Aircraft Company's semiconductor division for operation in circuits invented by Lenkurt Electric Co., Inc., a subsidiary of General Telephone & Electronics. Pointer indicates transistor mounted in circuit, both in development stages. Inventors believe both will lead to circuit simplification in communications equipment and possibly in electronic computers.

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SEMICONDUCTOR PRODUCTS is published monthly Cowan Publishing Corp. Executive and Editorial C fices: 300 West 43rd Street, New York 36, N. Y. Tel phone: JUdson 2-4460. Subscription price: $6.00 12 issues in the United States, U. S. Possessions, AP & FPO. Canada and Mexico. $6.00 for 12 issues. other countries: 12 issues $10.00. Single Copy 7 Accepted as controlled circulation publication Bristol, Conn. Copyright 1960 by Cowan Publishi Corp.

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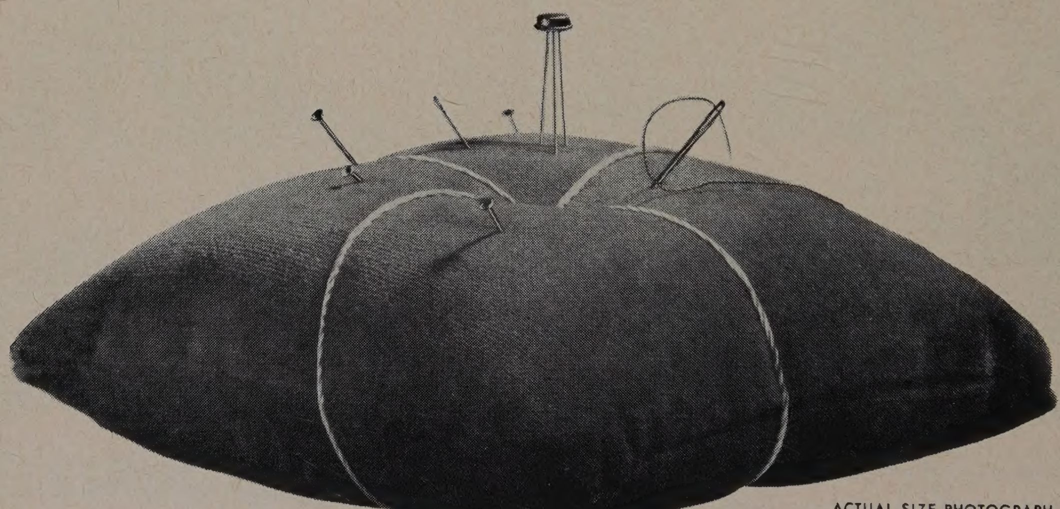

ACTUAL SIZE PHOTOGRAPH

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ELECTRICAL CHARACTERISTICS AT 25°C AMBIENT

PARAMETERS		TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
I_{CBO}	Collector Reverse Current	$V_{CB} = 30v$ $I_E = 0$	—	.005	1.0	μA
h_{FE}	D-C Forward Current Transfer Ratio	$I_C = 150ma$ $V_{CE} = 10v$	40	75	120	—
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_C = 150ma$ $I_B = 15ma$	—	0.7	1.5	v
h_{fe}	A-C Common-Emitter Forward Current Transfer Ratio	$I_C = 50ma$ $V_{CE} = 10$ v f = 20mc	2.5	5	—	—
C_{ob}	Collector Capacitance	$I_E = 0$ $V_{CB} = 10$ v f = 1mc	—	20	35	$\mu\mu f$
SMALL SIGNAL PARAMETERS						
h_{fe}	Small Signal Forward Transfer Ratio	$I_C = 1mA$ $V_C = 5$ v	30	70	—	—
h_{ib}	Common Base Input Impedance	f = 1KC	20	26	30	ohms
h_{rb}	Common Base Voltage Feedback Ratio		—	160×10^{-6}	250×10^{-6}	
h_{ob}	Common Base Output Admittance			.2	1.0	μmhos

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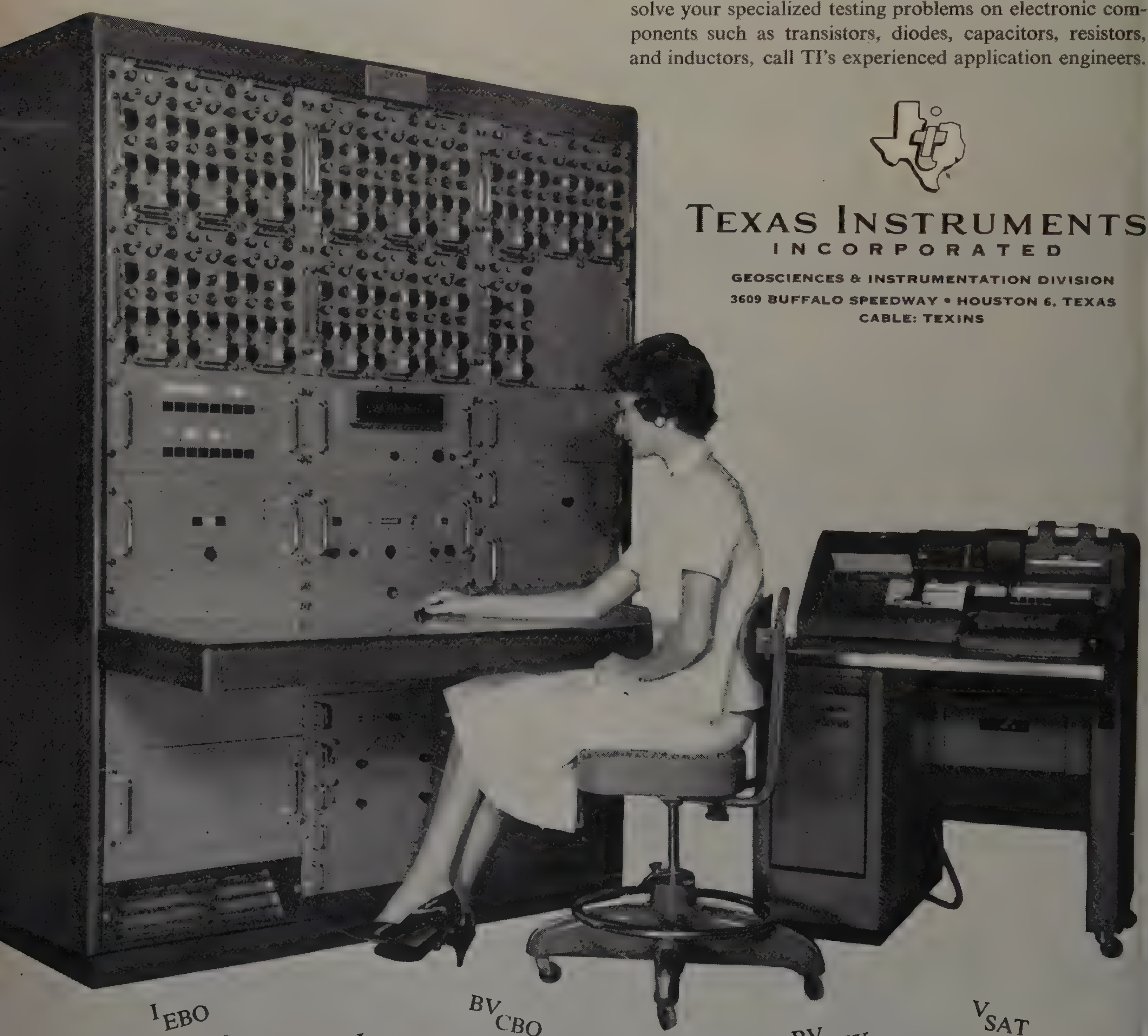

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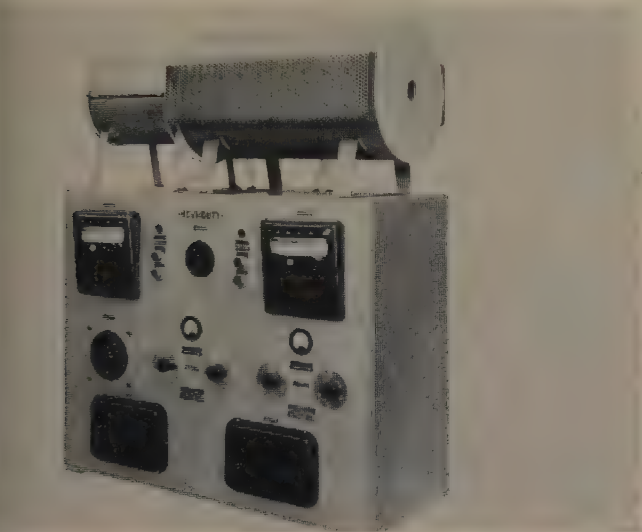

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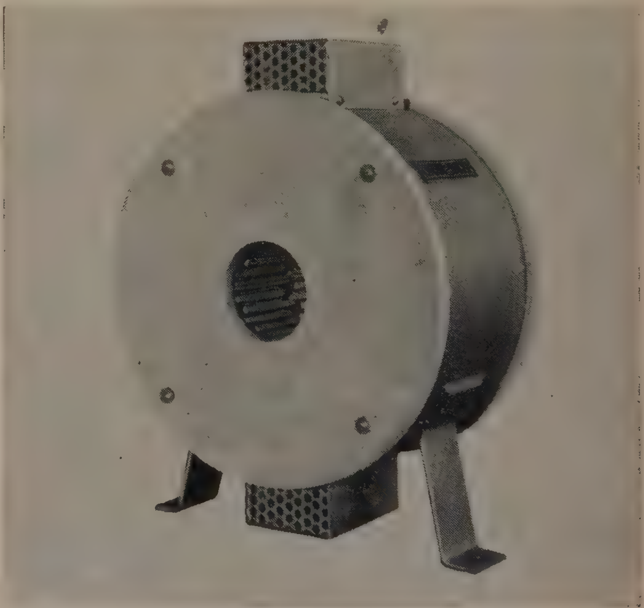
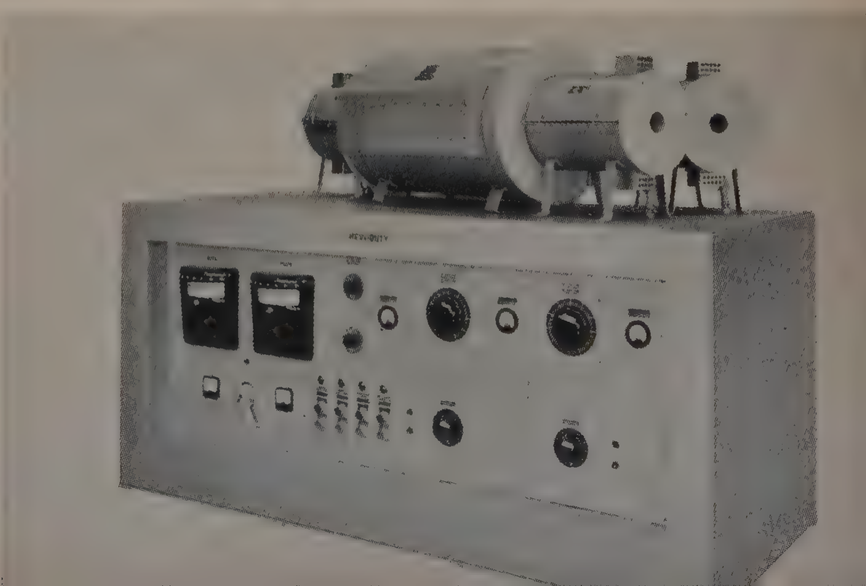


These two furnaces are being used successfully for the diffusion of silicon wafers. Boats are preheated in the small furnace to the right and then placed in the three-zone high-heat furnace. The cabinet contains saturable reactor controls that automatically maintain correct temperatures in each furnace.



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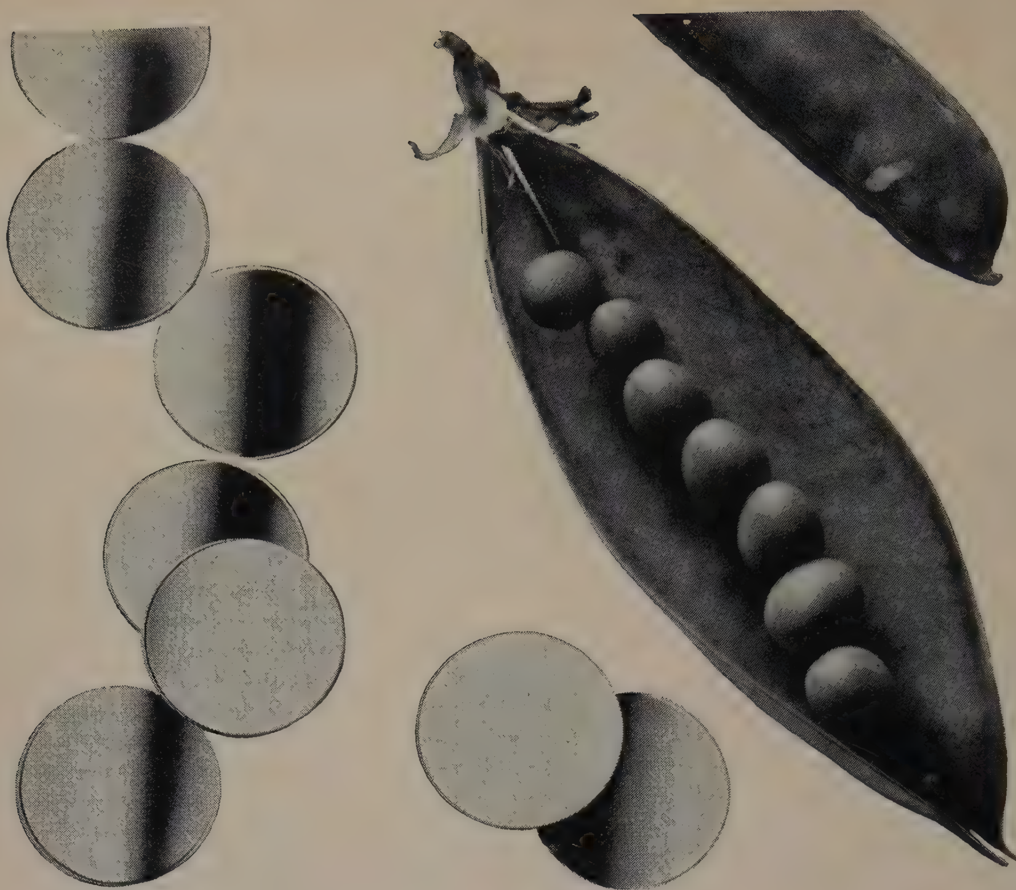

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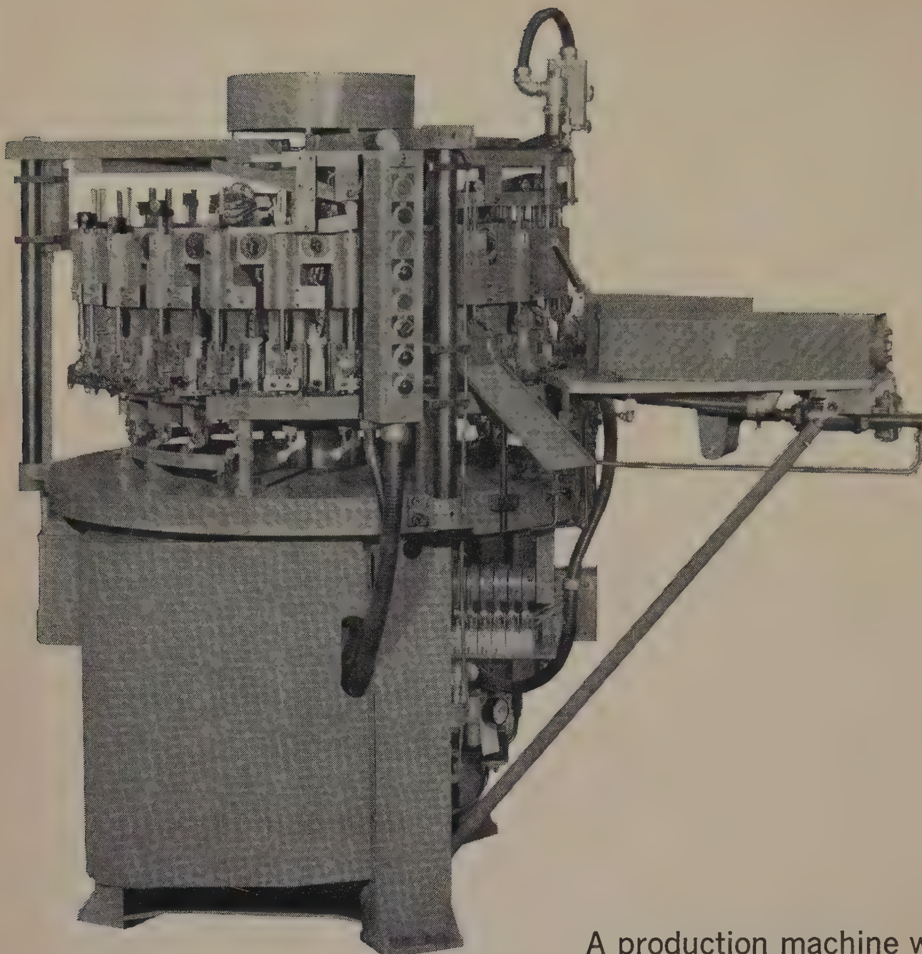


Editorial . . .

Plasma Phenomena

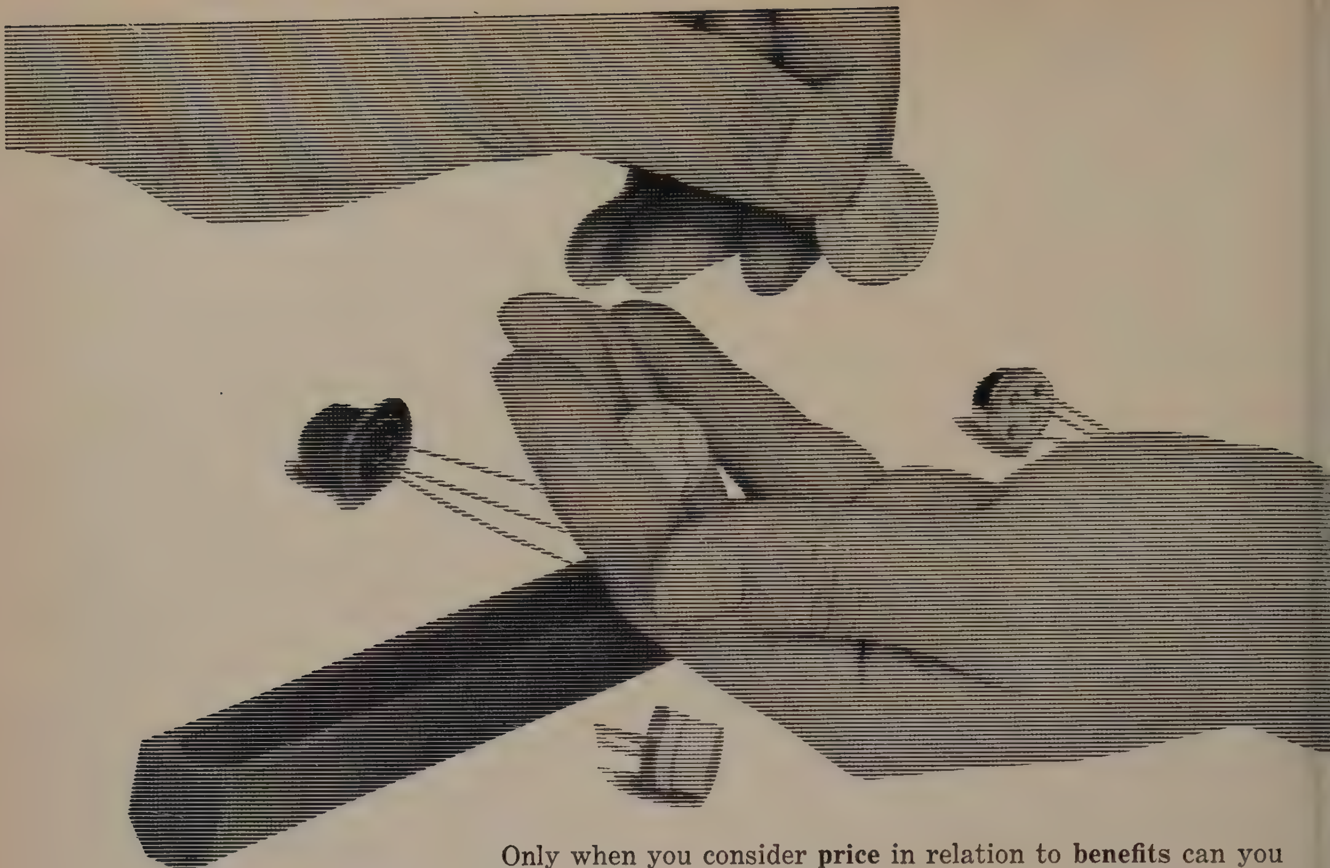
The phenomena which arise from the interaction of electric and magnetic fields in plasma are extremely complex, not only because of their nature, but also because of the simultaneous occurrence of several fundamental processes. The investigations of J. J. Thomson, Townsend, Langmuir, and others, have clarified many of the aspects of gaseous discharges, such as the existence of ranges of the voltampere characteristics having negative slope, the dependence of the breakdown voltage upon the "equivalent" the breakdown voltage upon the "equivalent" interelectrode spacing and the ambient pressure been noted in the case of semiconductors in connection with effects at the *p-n* junction and also with "bulk" conduction effects.

One of the interesting aspects of the electrical discharge is the presence of superposed random oscillations, which have the appearance of noise. In the case of reverse biased *p-n* junctions, it has been shown that such oscillations correspond to the localized discharges which take place at imperfections of the lattice. The noise is produced by random pulses, which generally can be described in terms of the time intervals during which the discharge is "on" or "off" and also in terms of the peak or of the average current. When the external load impedance is low, the resulting distribution is of Markoff type with asymptotic spectral dependence of the type ω^{-2}. When the load impedance is large, the "on" and "off" time intervals are interrelated and the interpretation of the nature of the noise becomes more complex.

Random oscillations are also obtained when a magnetic field is applied in a direction parallel to that of the current. Again these phenomena are found both in gaseous discharges and in semiconductors, although they differ in their characteristics and frequency ranges. Larrabee and Steele *(J.A.P.—September 1960)* have given a detailed investigation of the latter, using specimens of *n-* and *p-* type germanium, silicon and indium-antimonide. The effects are observed with (pulsed) currents of the order of 100 to 1000 A/cm^2 and with parallel magnetic fields of the order of 10,000 gauss. When a transversal component of the magnetic field is also present, the output oscillations tend to become sinusoidal of single frequency in the range of few kc/s to about 10 Mc/s. One of the possible explanations of the generation of the oscillations is based on the effect of the surface recombination velocity, which is a function of the carrier density near the surface. If the said velocity decreases with the increase of the carrier density, it is possible that an unstable equilibrium is realized between forces tending to push the plasma against the surface and diffusion fields which tend to counteract them.

The complexity of plasma phenomena is probably due to still imperfect understanding. However, the great promise that they present for applications and for the development of novel devices is attracting intensified research in many groups engaged in R&D.

Samuel L. Marshall



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Transistor Choppers

J. A. EKISS*

The transistor is finding wide application in chopper applications where it is desired to convert a low level *d-c* signal to an *a-c* voltage. In this application the transistor functions as a switch. This article is concerned with how the transistor should be characterized for this switching application and what transistor parameters influence performance. Several simple modulator and demodulator circuits are discussed which illustrate how the transistor is utilized in this application.

In SERVO-MECHANISM CONTROL SYSTEMS, analog computers, and instrument recorders there is often the need to convert a *d-c* (or low frequency) voltage to an *a-c* signal. The resulting chopped voltage may then be amplified by a conventional *a-c* amplifier. In theory this conversion of a *d-c* signal to an *a-c* signal may be accomplished by opening and closing a switch in such a manner that the signal is first switched across a load and then removed. The wave form of the *a-c* signal across the load will be a function of the wave form of the applied signal and the properties of the device used as the switch.

Certain types of transistors make excellent switches, i.e., they have two states: one in which they are conducting and one in which they are non conducting. This switching action is entirely analagous to the operation of a conventional electrical switch.

This article will characterize the transistor as a chopper and describe practical circuits for use in chopper applications.

Theoretical Considerations

Operating Regions

Transistor choppers utilize both the common emitter and the inverted connection (obtained by using the emitter as the collector and the collector as the emitter) depending on the intended application. For purposes of discussion let us assume that the common emitter connection is being used. (The following discussion is also valid for the inverted connection if words "emitter" and "collector" are interchanged.)

The transistor switch is characterized by three regions of operation. These are shown on the collector characteristics in *Fig. 1.* Region I corresponds to collector current cut-off (emitter and collector junction reverse biased); Region II is the active region (emitter forward biased and collector reverse biased); Region III corresponds to collector current saturation (emitter and collector junctions forward biased).

*Applications Engineer, Lansdale Tube Company, Lansdale, Pa.

From *Fig. 1* and the above definitions, we see that operation in Region I corresponds to an open switch and operation in Region III corresponds to a closed switch. Region II is a transition region between the open and closed conditions.

Offset Voltage and Current

The transistor is not a perfect switch, since when it is closed it has a finite voltage drop across it and when the switch is open it has a finite leakage current flowing through it. The voltage drop across the transistor when it is "on" (switch closed) is referred to in the literature as the "offset voltage", V_p[1]; the leakage current that flows in the transistor when it is "off" (switch open) is referred to as the "offset current", I_p.

1. The quantities V_p and I_p were originally defined by R. L. Bright in "Junction Transistors Used as Switches". V_p was defined as the collector-to-emitter voltage when the transistor was turned on with 1 *ma.* of base current. I_p was defined as the collector (or emitter) current when the transistor was turned off with a base to emitter voltage of 1 volt. In this article V_p is defined as the collector-to-emitter voltage when the transistor is conducting; I_p is defined as the collector (or emitter) current when the transistor is non-conducting.

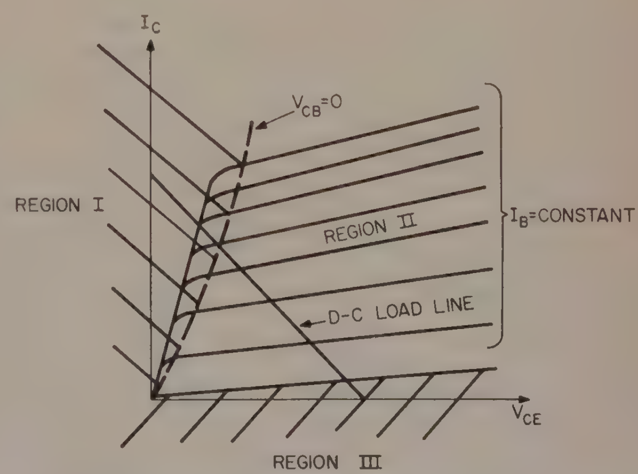

Fig. 1—The three regions of operation of the transistor chopper.

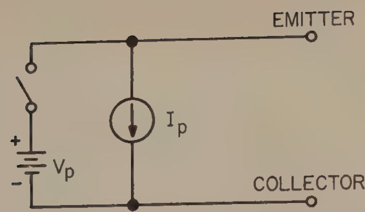

Fig. 2—Approximate equivalent circuit for the transistor chopper.

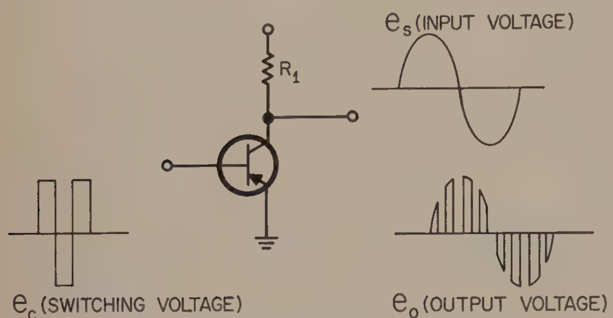

Fig. 3—Simple transistor modulator.

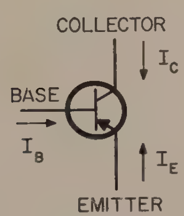

Fig. 4—The ideal transistor.

An *approximate* equivalent circuit for the transistor when used as a chopper thus consists of a perfect switch in series with a voltage source V_p and shunted by a current source as shown in *Fig. 2*.

The simple modulator[(2)] shown in *Fig. 3* will illustrate the effect of V_p and I_p on chopper performance. When the transistor is conducting we desire the output to be zero. When the transistor is non conducting we desire the output to be equal to the instantaneous value of the input signal. From the previous discussion of offset voltage and current it is evident that when the transistor is "on" the output will be V_p. In the "off" state the output will not be equal to the input signal but will be:

$$e_o = e_s - I_p R_1.$$

This shows that V_p and I_p limit the lowest magnitude of signal which may be chopped.

Therefore, in order to obtain an output voltage from the modulator proportional to the input signal, the effects of V_p and I_p must be minimized. The magnitude of V_p and I_p can be minimized by selection of certain transistors that have inherently low V_p and/or I_p and by utilization of the inverted connection previously described. The effects of given V_p and I_p values may be minimized by careful circuit design.

V_p and I_p may be related to fundamental transistor parameters. If we look at expressions for V_p and I_p in terms of these parameters, insight may be gained into the problem of how to select transistors for chopper applications.

Consider the "ideal transistor" of *Fig. 4* which has no spreading resistance associated with it. We will also assume that the base width is not dependent upon the collector voltage.

With the polarity for currents as shown, the following equations may be written relating I_C and I_E to the collector-to-base vlotage, V_C, and the emitter-to-base voltage, V_E[(3)]:

$$I_E = \frac{I_{E0}}{1-\alpha_N \alpha_I}\left(e^{\frac{qV_E}{kT}} - 1\right) + \frac{\alpha_I I_{C0}}{1-\alpha_N \alpha_I}\left(e^{\frac{qV_C}{kT}} - 1\right) \qquad (1)$$

$$I_C = +\frac{\alpha_N I_{E0}}{1-\alpha_N \alpha_I}\left(e^{\frac{qV_E}{kT}} - 1\right) - \frac{I_{C0}}{1-\alpha_N \alpha_I}\left(e^{\frac{qV_C}{kT}} - 1\right) \qquad (2)$$

In these equations

I_{E0} = saturation current of the emitter diode when $I_C = 0$.

I_{C0} = saturation current of the collector diode when $I_E = 0$.

α_N = D-C alpha of the transistor with the collector functioning as a collector and the emitter as an emitter (normal α).

α_I = D-C alpha of the transistor with the emitter functioning as the collector and the collector functioning as the emitter (inverted α).

q = charge of electron.

k = Boltzmann's constant

T = absolute temperature (°K).

V_C = collector-to-base voltage, defined as positive from collector-to-base.

V_E = emitter-to-base voltage, defined as positive from emitter-to-base.

In addition to Equations (1) and (2)

$$\alpha_N I_{E0} = \alpha_I I_{C0} \qquad (3)$$

The offset current corresponds to I_C when both the emitter and collector junctions are reverse biased. This current, denoted by I_p^N, is found by combining Equations (2) and (3) under the conditions that

$$e^{\frac{qV_E}{kT}} < < 1 \qquad (4)$$

$$e^{\frac{qV_C}{kT}} < < 1 \qquad (5)$$

2. A modulator is defined as a device that converts *d-c* to *a-c;* a demodulator is defined as a device that converts *a-c* to *d-c*.

3. J. J. Ebers and J. L. Moll, "Large-Signal Behavior of Junction Transistors", *Proc. I.R.E.;* December 1954.

Thus,

$$I_p^N = \frac{(1 - \alpha_I)\, I_{C0}}{1 - \alpha_N\, \alpha_I} \qquad (6)^{(4)}$$

The offset current for the inverted connection follows from Equation (6) by interchanging the superscripts "N" and "I" and replacing I_{C0} with I_{E0}.

$$I_p^I = \frac{(1 - \alpha_N)\, I_{E0}}{1 - \alpha_N\, \alpha_I} \qquad (7)$$

For non symmetrical[5], homogenous base transistors $\alpha_N > \alpha_I$ and $I_{E0} < I_{C0}$. Inspection of Equations (6) and (7) thus shows that $I_p^I < I_p^N$. I_p^I may be as much as two orders of magnitude less than I_p^N. Equations (6) and (7) also indicate that small I_p maybe achieved by keeping I_{E0} and I_{C0} small. This dictates the use of silicon transistors for applications where I_p must be minimized.

The offset voltage for the common emitter connection is V'_{CE} when the transistor is driven into the saturation region. The quantity V'_{CE} is defined in *Fig. 5*. Here, r'_c and r'_e are ohmic spreading resistances associated with the emitter and collector regions, respectively. From *Fig. 5*

$$V'_{CE} = I_C\, r'_c - I_E\, r'_e + V_{CE} \qquad (8)$$

Using Equations (1), (2), and the fact that

$$I_B + I_C + I_E = 0 \qquad (9)$$

one obtains:

$$V_{CE} = -\frac{kT}{q} \ln \frac{1}{\alpha_I} - \frac{kT}{q} \ln \frac{1 + \dfrac{\alpha_I}{\alpha_N}\dfrac{I_{C0}}{I_B} + \dfrac{I_C}{I_B}(1-\alpha_I)}{1 + \dfrac{I_{C0}}{\alpha_N I_B} + \dfrac{I_C}{I_B}\left(1 - \dfrac{1}{\alpha_N}\right)} \qquad (10)$$

The offset voltage is obtained by combining Equations (8), (9), and (10). This yields:

$$V_p^N = I_C\,(r'_c + r'_e) + I_B\, r'_e - \frac{kT}{q} \ln \frac{1}{\alpha_I}$$

$$- \frac{kT}{q} \ln \frac{1 + \dfrac{\alpha_I}{\alpha_N}\dfrac{I_{C0}}{I_B} + \dfrac{I_C}{I_B}(1 - \alpha_I)}{1 + \dfrac{I_{C0}}{\alpha_N I_B} + \dfrac{I_C}{I_B}\left(1 - \dfrac{1}{\alpha_N}\right)}. \qquad (11)^{(6)}$$

For applications where the input signal is small (low-level chopper) and the transistor is driven hard into saturation, Equation (11) reduces to:

$$V_p^N \cong I_B\, r'_e - \frac{kT}{q} \ln \frac{1}{\alpha_I}. \qquad (12)$$

---

4. In Equations (6) and (7) α_N and α_I are measured in the cut-off region (Region I).
5. A non symmetrical transistor is defined here as one in which the collector junction area is larger than the emitter junction area.
6. The α_N and α_I in this equation are to be measured at the "edge" of the saturation region.

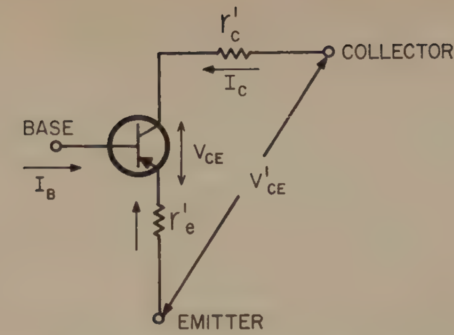

Fig. 5—The ideal transistor with spreading resistances.

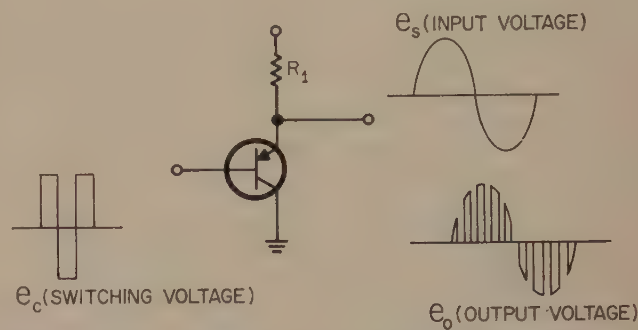

Fig. 6—Transistor modulator using the inverted connection.

For the inverted connection, the offset voltage is

$$V_p^I \cong I_B\, r'_c - \frac{kT}{q} \ln \frac{1}{\alpha_N}. \qquad (13)$$

Equations (12) and (13) show that if $r'_c \cong r'_e$, $V_p^I < V_p^N$, since $\alpha_I < \alpha_N$. Thus the use of the inverted connection leads to a lower offset voltage. V_p^N is minimized by keeping the emitter spreading resistance small, α_I large, and I_B (the base driving current) as small as practicable; V_p^I is minimized by small r'_c, large α_N, and small I_B.

At this point it may be well to emphasize the fact that not only do V_p and I_p depend on transistor parameters but they also depend on the operating conditions under which they are measured. The expressions shown for I_p Equations (6) and (7) are voltage dependent since I_{C0} and I_{E0} contain leakage components which are voltage dependent. The dependence of V_p on operating conditions is explicit to some degree in Equations (12) and (13). V_p is dependent on I_B. I_p and V_p are, of course, temperature dependent. I_{C0} and I_{E0} approximately double for each 10° C increase in temperature. Since α_I and α_N increase slightly with temperature, V_p increases only slightly with temperature. When V_p and I_p are specified, the conditions under which the measurements are made should be given.

Practical Applications

Circuits

The circuit shown in *Fig. 3* is one form of modulator that may be used in conjunction with an *a-c* amplifier

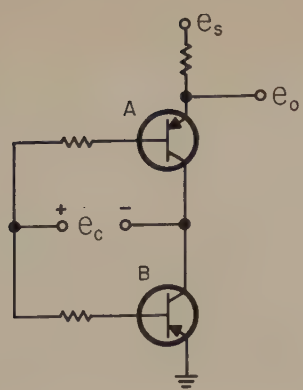

Fig. 7—Modulator circuit which will chop *a-c* signals.

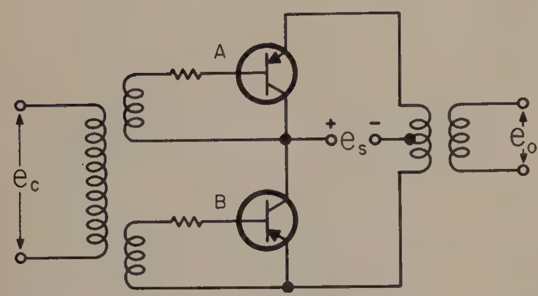

Fig. 8—Modulator circuit in which the offset voltages cancel.

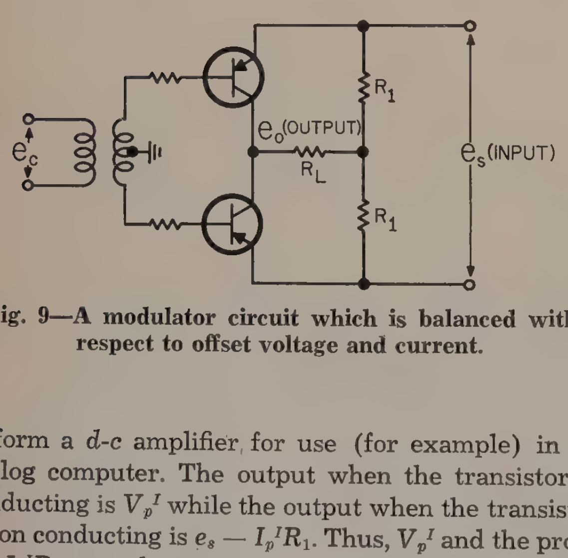

Fig. 9—A modulator circuit which is balanced with respect to offset voltage and current.

to form a *d-c* amplifier for use (for example) in an analog computer. The output when the transistor is conducting is V_p^I while the output when the transistor is non conducting is $e_s - I_p^I R_1$. Thus, V_p^I and the product $I_p^I R_1$ must be minimized if the chopped output is to be proportional to the input. When the chopper is used to modulate very low input voltages, the inverted connection should definitely be used. If circuit design necessitates the need for a large R_1, silicon transistors should be utilized in this circuit because of their low I_p^I. If R_1 may be kept small so that V_p^I is large with respect to $I_p^I R_1$, germanium transistors should be used because their V_p^I is generally lower than V_p^I of silicon.(7) One disadvantage of this circuit is that it will not chop positive input signals greater than the base-to-collector voltage holding the transistor off. This is not a serious disadvantage except in applications where the signal to be chopped is large.

A novel circuit(8) that may be used to chop *a-c* input signals is shown in *Fig. 7*. e_c is a square wave switching voltage with instantaneous polarity as shown, e_s is the *a-c* input signal to be modulated. With the polarities as shown transistor B is cut-off so the output is approximately equal to the input signal. If e_c is large enough ($e_c > 1$ volt), then transistors A and B may be represented as two current sources I_{pA}^I and I_{pB}^I which are of opposite polarity, thus tending to cancel one another out. The output voltage will thus be

$$e_0 = e_s - (I_{pA}^I - I_{pB}^I)\, R_1. \qquad (14)$$

We see that the offset currents tend to cancel.

If the polarity of the chopping voltage, e_c, is reversed, both transistors will conduct. Transistors A and B may be represented as two batteries in series of magnitude V_{pA}^I and V_{pB}^I. These voltages are of opposite polarity and hence tend to cancel. The output voltage for this half cycle of e_c is

$$e_0 = V_{pB}^I - V_{pA}^I. \qquad (15)$$

With proper selection of transistor pairs, the effects of V_p and I_p may be minimized. Transistors should be selected on the basis of matched offset voltages rather than attempting to match offset current. I_p is quite temperature sensitive so matching at one temperature would not guarantee cancellation of offset current. Furthermore, there is some control on the effect of I_p through the resistance R_1.

There is some possibility to control the magnitude of V_p as inspection of Equations (12) and (13) show.

$$V_p^I = I_B\, r'_c - \frac{kT}{q} \ln \frac{1}{\alpha_N} \qquad (13)$$

The magnitude of V_p^I may be adjusted by changing r'_c with external resistance. This method of balancing will work if I_B is regulated.

A modulator circuit(9) in which the offset voltages cancel is shown in *Fig. 8*. e_c is a square wave switching voltage; e_s is the *d-c* input signal. With transistor "A" conducting, the output, e_{out}, will be $e_s - V_{pA}$ (for a total primary to secondary turns ratio of 2:1). With transistor "B" conducting and transistor "A" cut-off, the output is $e_s + V_{pB}$. Therefore, the peak-to-peak output voltage is e_s provided $V_{pA} = V_{pB}$.

e_s can be no larger than the magnitude of the base-to-collector voltage holding the transistor *off*.

As a final example of the use of transistors as choppers, a demodulator circuit is shown in *Figure 9*.(10)

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7. That V_p^I for germanium transistors is generally less than V_p^I for silicon transistors follows from the fact that B_N of silicon units is, in general, less than B_N for germanium units.
8. R. L. Bright "Junction Transistors Used as Switches", Paper 55-156, *Transactions of the AIEE;* March, 1955.
9. See A. J. Williams, et al, "Some Advances in Transistor Modulation for Precise Measurement", Leeds and Northrup Company, Philadelphia, Pa.
10. See L. P. Hunter, "Handbook of Semiconductor Electronics", McGraw-Hill Book Co., New York, N. Y.; 1956.

This circuit is used to convert the *a-c* input signal to a *d-c* output proportional to the input. For the circuit to function properly, the square wave switching voltage, e_c, must be either in phase with the input signal or 180° out of phase with it. The circuit is balanced with respect to the offset voltage and current so that the *d-c* output due to these quantities is minimized. (See *Fig. 10.*)

If we define e_{01} as the output due to $V_{pA}{}^I$, then the output due to these quantities[11] ($e_s = 0$) is:

$$e_{01} = \frac{R_L}{R_1 + R_L} V_{pA}{}^I - \frac{R_L R_1}{R_L + R_1} I_{pB}{}^I \tag{16}$$

Similarly, when transistor "B" is conducting,

$$e_{02} = \frac{R_L}{R_1 + R_L} V_{pB}{}^I - \frac{R_L R_1}{R_L + R_1} I_{pA}{}^I \tag{17}$$

Thus, these components of the output may be minimized by selection of transistors and adjustments of R_L and R_1. In particular for $R_L = R_1 = V_p/I_p$, $e_{01} = e_{02} = 0$.

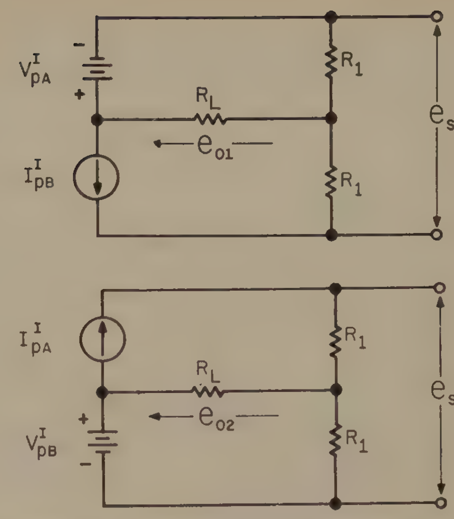

Fig. 10—Equivalent circuits for the demodulator for one cycle of the switching voltage.

Summary of Considerations in the Selection of Transistors for Chopper Applications

1. For low level applications where very small signals are being chopped, particular attention must be given to V_p and I_p. We have seen that silicon transistors have a lower offset current than germanium transistors. Thus, in applications where I_p is important, silicon transistors should be employed. In applications where V_p is of primary importance, germanium transistors should be used.
2. In applications where the signals to be chopped are much larger than the offset quantities, germanium units should be used.
3. In addition to the above two comments transistors used in high frequency choppers must have good high frequency switching characteristics. The rise, fall, and storage times should be small with respect to the reciprocal of the frequency of the modulating voltage. In general, the frequency of the modulating voltage should be at least ten times the frequency of the input signal.

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11. The assumption is made here that the input voltage is derived from a high impedance source.

Resistivity, Crystal Perfection, and Lifetime Measurements for Germanium and Silicon Monocrystals

DR. A. S. TULK*

Present developments in the semiconductor industry include increased reliance of device manufacturers on sources of monocrystals other than their own materials department. One of the problems which must be faced by the purchaser of crystals from an "outside" source is the degree of trust which he can place in the evaluation by the supplier. Not only must the identity of the measurement be known to the purchaser, but much of the detail of the measurement method must also be familiar to him.

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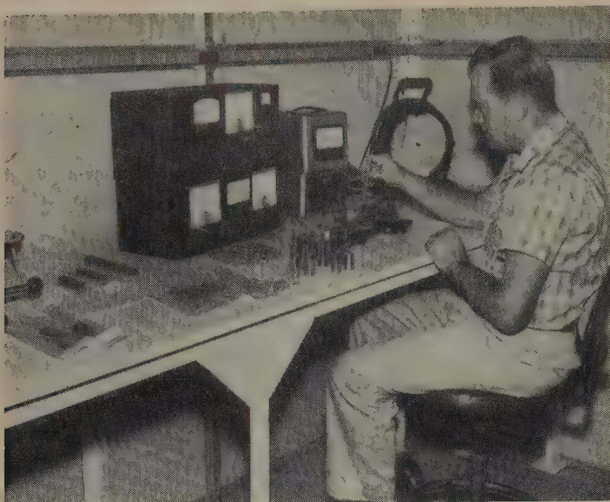
In the subsequent discussion, a measuring procedure for germanium and silicon monocrystals will be outlined in considerable detail.

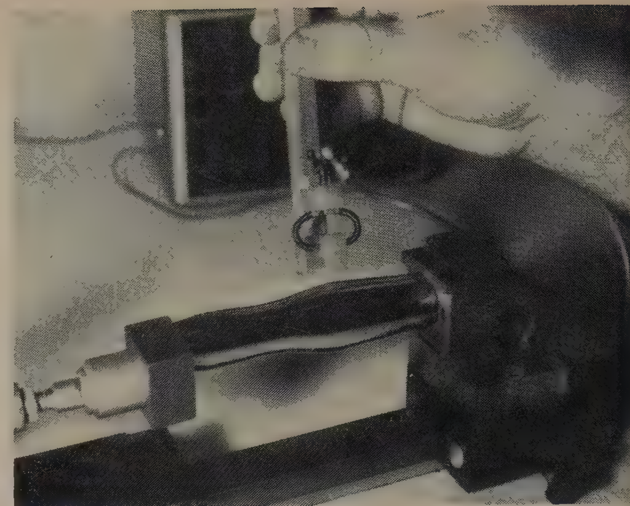
Germanium Resistivity

The surface on which the resistivity readings are taken must be smooth and abraded. If a diamond cut-off wheel is used to cut the crystal to length, the surface is usually satisfactory. A flat area about one centimeter in width is ground along the side of the crystal with a diamond wheel if readings are to be made longitudinally.

A measurement is made along the side of a mono-



The determination of the resistivity profile of a silicon monocrystal by means of the two-point probe. The current is supplied to the crystal from the power supply at the left, and potential between the probes is read on the vacuum-tube voltmeter in the center.



Close-up of the two-point probe being used on a silicon monocrystal. The tungsten probes are applied to the crystal along an abraded strip. The lead-faced jaws of the clamp make the current contacts to the crystals.

crystal only when a complete profile is desired. This is accomplished by the two-point-probe method at regular intervals. It is more usual to take readings on the ends of the crystal with a four-point probe. From five to ten such readings are made about the center of the cut face and the low reading is recorded.

A similar number of readings are then taken near the outer edge of the crystal. The probes are aligned along the radii of the crystal and care is taken to place the outermost probe no closer than six millimeters from the edge of the face. The highest reading of this group is recorded.

All the readings must be within the desired specification. If any are not, a slice, several millimeters thick, is cut from the faulty end and the readings are repeated.

All measurements are made in an electrically shielded room whose temperature is maintained at 27°C (300°K). Because the resistivity of intrinsic germanium is very sensitive to temperature, crystals whose resistivities approach theoretical are allowed to remain in the measuring room for at least two hours to ensure thermal equilibrium.

The probes used in the four-point-probe method are made of tungsten or hardened steel. These are accurately positioned in a straight line, 0.050 inch apart. The current passed through the outer probes is 0.80 milliampere and the resistivity is read directly by means of a Millivac vacuum-tube voltmeter (Model 17-C or 27-C) between the inner probes.

When a two-point scan is made along the side of the germanium monocrystal, a vise with insulated end contacts of lead is used to hold the piece. A current of about one milliampere is passed through the crystal. With highly doped crystals it is often necessary to use a higher current to increase the potential drop from point to point to a measurable value. These probes are also made of tungsten or hardened steel and are spaced 0.030 inch apart. The potential between them is read by the vacuum-tube voltmeter described above. The resistivity is then calculated from the equation:

$$\rho = \frac{E}{I} \times \frac{A}{d},$$

in which E is the measured potential (mv), I is the current (ma), A is the cross-sectional area (cm^2), and d is the probe spacing (cm).

Silicon Resistivity

All resistivity measurements on silicon monocrystals are made by the two-point-probe method. The ends of the crystal are cut off and the cut faces are made parallel to each other with a diamond cutoff wheel. A narrow flat strip is ground along one side of the crystal with a diamond grinding wheel and the crystal is clamped in the lead-faced vise.

The two-point probe described for germanium is used and readings are taken at one-centimeter intervals. The lowest possible current is used through the crystal. This is usually in excess of one milliampere, however. The calculations are the same as those used for germanium.

Because of the difficulty encountered in making ohmic contacts to silicon, readings are checked with the current direction reversed. If the two sets of readings do not agree, the ends of the crystal are recut and the measurements repeated.

All silicon monocrystals are checked for the presence of photovoltaic effects which are usually associated with steep impurity gradients in the crystal. All leads are removed from the vise and the probe is placed in contact with the silicon. If a reading is obtained on the vacuum-tube voltmeter, it is recorded and compared to the readings made for resistivity calculations. If a photovoltage is observed which exceeds five percent of the voltage read when current

s flowing, the resistivity determination is in doubt and the crystal is rejected. Photovoltages are usually not encountered on fairly heavily doped silicon monocrystals.

Germanium Crystal Perfection

Crystal perfection is studied on a <111> face. Slices, one to three millimeters in thickness, are cut from each end of the crystal. The side of the slice which was next to the main part of the crystal is lapped on a flat glass plate with a water slurry of silicon carbide. Initial grinding is done with 250-mesh grit. This is followed by 400-mesh grit and the finish lapping is carried out with 600-mesh grit. The lapping process may also be carried out mechanically on an iron lapping plate with 800-mesh Alundum.

The slices are washed in deionzeid water and are then air-dried before being etched in CP4 for three minutes. The acid etch is then followed by a second washing in deionized water and air-drying.

If the crystal has been grown by the vertical technique, three diameters, each of which is perpendicular to one of the major flats on the sides of the crystal, are lightly scribed across the face of the slice. One point is marked on each radius such that the six points describe a spiral from the center to the outer edge of the slice. Etch-pit counts are made at each of these points and at the center of the slice. Etch-pit counts on zone-levelled crystals are made by the same technique except that the points at which the counts are made are chosen arbitrarily.

Surface illumination is used with a projection microscope at a magnification of 100X. An area of 1.0 mm^2 is counted at each of the seven points and the slice is scanned for the area of highest etch-pit density. Lineage, if present, is also detected during this scanning operation.

The average of the seven readings is reported as the "average etch-pit density" while the count obtained at the point of greatest density is reported as the maximum for the slice.

If the required maximum specification is expected, a piece about two-centimeters thick is cut from the crystal and the determination is repeated.

Minority Carrier Lifetime in Germanium

Lifetimes of minority carriers are measured by the photoconductive-decay technique on the whole crystal.

The crystal is etched for two minutes in CP4, washed in deionized water, and air-dried. To permit the making of ohmic contacts, the ends of the crystal are abraded with 240-mesh silicon carbide. Care is taken during this operation to keep the etched surface of the crystal clean.

The crystal is clamped in a vice whose face plates are of plastic covered with copper braid which act as end contacts to the crystal. A battery and a large resistance are connected in series with the sample and the smallest possible current used.

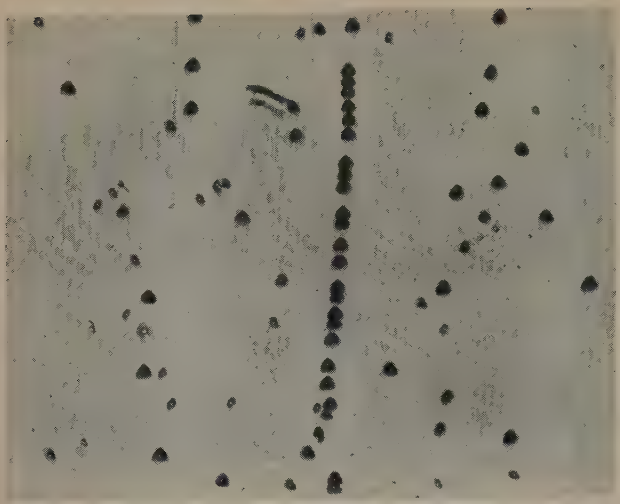
The use of the four-point probe to determine the resistivity of the end of a germanium monocrystal. Care is taken to keep the probes at least six milimeters from the edge of the face.

Germanium crystal showing the method used for determination of the points to be studied in etch-pit counting. For purposes of illustration the lines have been drawn heavily with a pencil. Normally, a tungsten or tungsten carbide scriber is used.

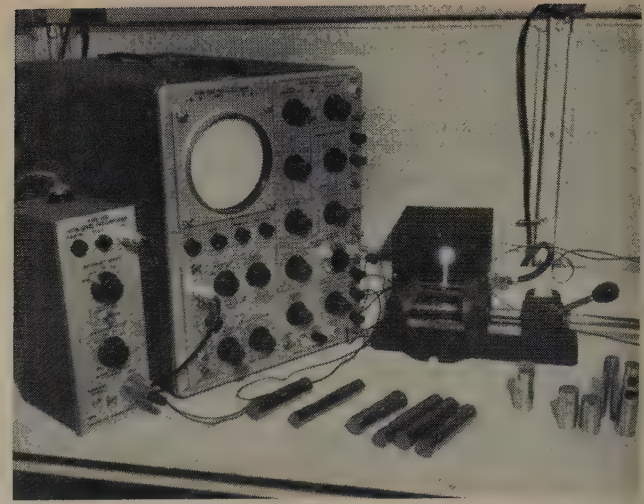
The light source used is a General Radio Strobolux and the decay curve is displayed on a Tektronix Oscilloscope, Model 535, equipped with a 53/54D amplifier. When low resistivity material is evaluated, the small signal necessitates the use of a Tektronix Type 122 Preamplifier.

The lifetime is determined as the decay constant, τ, of the exponential decay curve, $I = I_0 e^{-\frac{t}{\tau}}$, where I_0 is the height of the curve at time t_0 and I is the height of the curve at time t.

Readings are also taken with the current reversed. If a significant difference is seen in the readings, the lifetime is suspect. A scan of the bar, taken with no bias current, should result in no signal on the oscilloscope. If a photovoltaic effect is seen, no reliable lifetime data can be obtained.



Photomicrograph of a piece of germanium monocrystal, cut on the <111> plane and etched to reveal dislocation. The total area shown is about one square millimeter. The fine, continuous line is a reference mark made by a tungsten scriber. The aligned etch pits running through the center of the field are an example of lineage.



A minority-carrier-lifetime determination on a germanium monocrystal. The light source is contained in the black box in the background, and the bias voltage is applied to the crystal by a power supply which is not shown. The amplified signal from the crystal is displayed as an exponetial curve on the oscilloscope.

Minority Carrier Lifetime in Silicon

The techniques and apparatus used to determine the minority-carrier lifetime in silicon are exactly the same as those used for germanium with one exception: it is necessary to plate the ends of the silicon monocrystal with gold to permit a good ohmic contact to be made with the copper braid of the vise.

Orientation—Silicon and Germanium

All monocrystals are grown from well oriented seeds which are carefully aligned in the chuck of the crystal puller. The orientation of the crystal is also checked after growth by either an optical or an x-ray technique.

Introduction to Semiconductor Theory and Reverse Breakdown*

C. A. ESCOFFERY, Ph.D.**

Part 3

Reverse Breakdown

For our present discussion, the most important region in the voltage-current characteristics of the silicon rectifier is that of high reverse bias, leading to *reverse breakdown* and its utilization in numerous devices and applications. It is beyond the scope of this article to present a detailed discussion of the breakdown mechanism, but an account of some of the present-day thoughts on the matter is desirable, to provide a better understanding of Zener diodes.

Fig. 10 illustrates schematically the current-voltage relationships in a reverse-biased silicon diode. At low voltages, only a very small current flows, which, as we have seen, is due to the drift of thermally generated minority carriers. In an ideal diode, this current would saturate at a relatively low value, given by Eq. 17.

In practice, however, the current is not completely voltage-independent. The reasons for departure from the ideal case are attributed to surface effects, channels, inversion layers, and gross defects in the body of the junction.[13-17] Some recent data[18] appears to indicate that in silicon with short lifetime, bulk recombination centers are responsible for the large space-charge generated currents; as the lifetime is increased, however, the surface leakage currents become predominant.

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*This is a reprint of an article which appeared in the "Zener Diode Handbook," published by International Rectifier Corp.

**International Rectifier Corporation

Looking again at *Fig. 10*, we notice that as the reverse voltage is increased the leakage current remains essentially constant until a certain critical voltage, the *breakdown voltage*, is reached, at which point the current increases by many orders of magnitude. This is the breakdown region, and the current is known as the Zener current or the avalanche current, as explained further on below.

The breakdown point is of great interest not only in theory but also in practice, since the reverse voltage which can be imposed on rectifiers and other semiconductor devices is determined by it. In conventional diodes and rectifiers, it is desirable, if not mandatory, to operate considerably below the breakdown point; Zener or avalanche diodes, on the other hand, are designed to operate at the breakdown point.

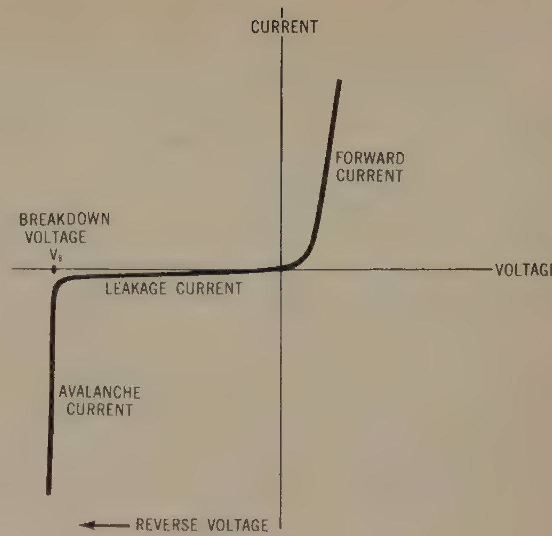


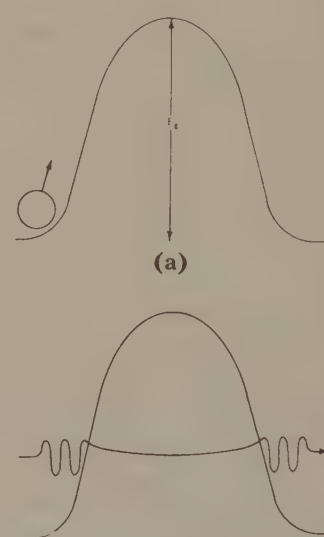
Fig. 10—Current-voltage characteristic of a typical *p-n* junction.

Zener Breakdown

Just what causes the very rapid rise in current at the breakdown point? For some time this question was an interesting and challenging one, but numerous experiments and theoretical analyses which have been made in recent years have added considerably to our knowledge of the mechanism of reverse breakdown.

Two types of breakdown have been considered, the Zener type and the avalanche type. In the early days of semiconductor device development it was believed[19] that the Zener mechanism was responsible for breakdown in germanium and silicon diodes. Devices, therefore, designed to utilize the breakdown phenomenon came to be known as Zener diodes. At the present, it is believed that both mechanisms may be operative, with the avalanche process being the predominant one, especially at reverse voltages above about six volts. Consequently, the term avalanche diode may be more appropriate but, rightly or wrongly, the designation Zener diode is likely to remain.

The Zener effect, so-called because it is based on a theory originally developed (for dielectrics) by C. Zener,[20] is actually a case of internal field emission. Under very intense fields (of the order of 3×10^5 volts/cm), electrons can be made to traverse the forbidden energy gap by a process known as quantum-mechanical tunneling.*



(a)

(b)

Fig. 11—(a) An electron with energy less then E_g cannot cross over the potential barrier, according to classical mechanics; (b) In quantum mechanics, the electron is considered as wave motion and there is a finite probability of it "tunneling" through the potential barrier.

If the energy gap is likened unto a hill (potential barrier), classical mechanics tells us that electrons on one side of the hill cannot reach the other side unless they have sufficient energy to climb over the hill.

In the new, quantum mechanics such a limitation does not exist, however, and there is a statistical probability of finding electrons on the other side (Fig. 11). This probability, P, is given by an expression of the following type

$$\log P = \text{constant}\ \frac{E_g^{3/2}}{E} \qquad (18)$$

*This tunneling process appears to take place in the recently announced diodes developed by Esaki[21] and which have come to be known in this country as "tunnel diodes."

where E_g is the energy gap and E is the applied field. When E is large, the probability approaches unity. Further calculations convert the probability into an actual current which is a function of the applied high electric field.

It is also possible to obtain equations relating the breakdown voltage to the resistivity of the semiconductor on each side of the junction.

In the case of abrupt silicon *p-n* junctions, the Zener breakdown voltage is given by

$$V_z = 39\rho_n + 8\rho_p \qquad (19)$$

where ρ_n and ρ_p are the resistivities in the n and p sides, respectively.

This equation, however, does not agree with experimental facts. For instance, Zener diodes made with 0.1 ohm-cm n-type silicon (p-side resistivity negligible) have a Zener voltage of about 15 volts instead of the 3.9 predicted by Eq. 19.

Avalanche Breakdown

As experimental data appeared indicating lack of agreement with the Zener theory, doubts arose as to its validity in explaining breakdown in silicon and germanium diodes. The avalanche mechanism proposed by McKay[22, 23], and elaborated by Wolff,[24] is now believed to be more in accord with the facts. It is similar to the process which occurs in an electrical discharge in gases, the theory of which was developed by Thompson.[25]

It will be recalled from our discussion of the reverse-biased p-n junction that the reverse current is due to the drift of minority carriers (holes in the n-side and electrons in the p-side) across the junction. In the avalanche process we visualize these carriers as being accelerated by the increasing voltage to higher and higher velocities. Eventually, they acquire sufficient energy* to be able to strip off (ionize) bound valence electrons from the silicon atoms.

It should be noted that when an electron is knocked off from the parent atom a positive hole is automatically created. Every ionizing carrier (hole or electron) therefore creates *two* additional carriers. These new carriers are now, in turn, capable of being accelerated by the high field and of creating additional electron-hole pairs! One can readily see that this cumulative process is one of rapid multiplication of carriers, leading to a tremendously rapid increase in reverse current.

*The critical energy, or the "threshold for pair-production," by electrons in silicon is about 2.25 electron volts.[26] See also Refs. 24 and 28.

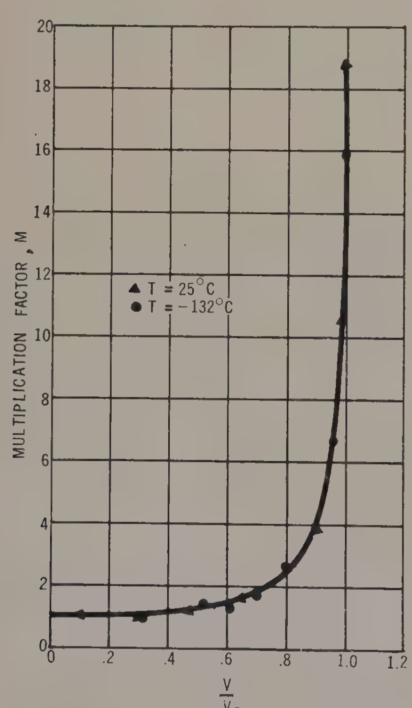


Fig. 12—Multiplication curves for a linear gradient junction with the voltage scale normalized to the breakdown voltage for different temperatures. (After McKay[23]).

An important parameter in the avalanche theory is the *ionization coefficient*, α, which can be considered as the number of ionizing collisions a given carrier makes in one cm. path length. In other words, α is the number of electron-hole pairs created by a single carrier (electron or hole) as it travels one cm. under the applied electric field.

By means of suitable experiments and making certain assumptions (for instance, that α is the same for electrons as for holes) it is possible to determine values of α as a function of the applied field. This has been done[22] for different types of junctions, and the values obtained range from about 800 at an electric field strength of 200 kv/cm (across the p-n junction) to about 60,000 at a field strength of 500 kv/cm. Above these voltages, the ionization coefficient appears to saturate.

The actual determination of α is done through measurements of the *multiplication ratio, M,* which is the ratio of the current leaving the junction to the current entering the junction. Multiplication, as we have seen, occurs even before we reach the breakdown voltage. By illuminating one side of the junction or bombarding it with alpha particles, one can inject carriers into it at voltages below the breakdown voltage and determine M from a study of the V-I characteristics.[22] A typical multiplication curve[23] is shown in *Fig. 12.*

It can be shown that the multiplication ratio M is related to the ionization coefficient α by means of the following expression

$$1 - \frac{1}{M} = \int_{o}^{w} \alpha(E)dx \qquad (20)$$

where w is the width of the barrier. Solutions to the above equation can be obtained for different types of junctions. Thus, for a silicon step junction (alloy type) one obtains

$$\alpha = 1.52 \times 10^{-7} N_I \frac{d\left(1 - \frac{1}{M}\right)}{dE_m} \qquad (21)$$

where E_m is the maximum field, and N_I is the net impurity density (donors minus acceptors).

Values of the parameter α obtained from multiplication experiments agree quite well with those predicted theoretically according to the theory developed by Wolff.[24]

The above discussion assumed that α was the same for both electrons and holes. Subsequent experiments have indicated that this is not actually the case,[27-29] and the mathematical analysis becomes more involved.

Turn page for characteristics of 91 typical CLARE Transistors....

PNP

LOW VOLTAGE GERMANIUM ALLOY

TYPE	CHARACTERISTICS (25 ±3°C)												APPLICATION		
TO-5 Case Outline	Max. Diss. (mW) 25°C Ambient	T_j (°C)	f_{ab} (mc)		BV_{CBO} (Vdc)	BV_{EBO} (Vdc)	V_{RT}* (Vdc)	h_{FE}			h_{fe}		SMALL SIGNAL AMPL.	LOW CURRENT SWITCH	HIGH CURRENT SWITCH
		Max. Rated	Min.	Typ.	Min.	Min.	Min.	I_C (mAdc)	Min.	Max.	Min.	Typ.			
2N315A	150	85	–	5	−25	−20	−25	−100	20	50				X	
2N316A	150	85	8	12	−25	−20	−20	−200	20	50	–	150			X
2N317A	150	85	15	20	−20	−20	−15	−400	20	60	100	200			X
2N395	150	85	3	4.5	−30	−20	−15	−10	20	–				X	
2N396	150	85	5	8	−30	−20	−20	−200	15	–					X
2N397	150	85	10	12	−30	−20	−15	−200	20	–					X
2N404	150	100	4	12	−25	−12	−24	−20	40	–				X	
2N413	150	85	–	2.5	−30	−20					–	30	X		
2N414	170	85	3.5	7	−30	−20	−20	−20	30	–	40	80	X	X	
2N416	170	85	8	10	−30	−20	−15	−20	40	250	60	100	X	X	
2N417	170	85	15	20	−30	−20	−15	−20	60	180	80	150	X	X	
2N425	170	85	2.5	4	−30	−20	–	−100	10	–				X	
2N426	170	85	3	6	−30	−20	–	−100	10	–				X	
2N427	170	85	5	11	−30	−20	−22	−150	15	–				X	
2N428	170	85	10	17	−30	−20	−18	−200	20	–					X
2N519A	150	85	0.5	–	−20	−10	−20	−20	20	50	15	25	X	X	
2N520A	150	85	3	–	−20	−10	−20	−20	40	170	40	100	X	X	
2N521A	150	85	8	–	−20	−10	−18	−20	60	250	70	150	X	X	
2N522A	150	85	15	–	−20	−10	−15	−20	80	320	100	200	X	X	
2N523A	150	85	21	–	−20	−10	−10	−20	100	400	125	300	X	X	
2N578	150	85	3	5	−20	−12	−15	−400	10	–					X
2N579	150	85	5	8	−20	−12	−15	−400	20	–					X
2N580	150	85	10	15	−20	−12	−15	−400	30	–					X
2N581	150	85	4	8	−18	−10	−15	−20	20	–				X	
2N582	150	85	14	18	−25	−12	−15	−20	40	–				X	
2N658	170	85	2.5	5	−25	−12	–	−150	15	–				X	
2N659	170	85	5	10	−25	−12	–	−250	25	–					X
2N660	170	85	10	15	−25	−12	–	−400	40	–					X
2N661	170	85	15	20	−25	−12	–	−550	55	–					X
2N662	170	85	4	8	−25	−12	–	−180	18	–				X	
2N1017	170	85	15	20	−30	−20	–	−200	20	–					X
2N1018	170	85	20	25	−30	−20	–	−300	30	–					X
2N1303	150	85	3	4.5	−25	−25	−25	−200	10	–					X
2N1305	150	85	5	8	−25	−25	−20	−200	15	–					X
2N1307	150	85	10	12	−25	−25	−15	−200	20	–					X
2N1309	150	85	15	20	−25	−25	−15	−200	20	–					X

MEDIUM POWER GERMANIUM ALLOY

2N597**	250	100	3	8	−45	−45	−40	−200	20	–					X
2N598**	250	100	6.5	10	−35	−30	−35	−200	50	160					X
2N599**	250	100	12	18	−30	−20	−20	−200	75	–					X

**TO-9 Case Outline, collector internally connected to case.

DIFFUSED BASE (DRIFT) GERMANIUM ALLOY

TYPE	CHARACTERISTICS (25 ±3°C)											APPLICATION		
TO-5 Case Outline	Max. Diss. (mW) 25°C Ambient	T_j (°C)	f_T Gain Bandwidth Product (mc)		BV_{CBO} (Vdc)	BV_{EBO} (Vdc)	V_{RT}* (Vdc)	h_{FE}				SMALL SIGNAL AMPL.	LOW CURRENT SWITCH	HIGH CURRENT SWITCH
		Max. Rated	Min.	Typ.	Min.	Min.	Min.	I_B (mAdc)	I_C (mAdc)	Min.	Max.			
2N602	120	85	10	20	−20	−1	−20	−0.5	–	20	80		X	
2N603	120	85	30	40	−30	−1	−20	−0.5	–	30	100		X	
2N604	120	85	50	60	−30	−2	−30	−0.5	–	40	140		X	
2N643	120	85	20	30	−30	−2	−29	–	−5	20	–		X	
2N644	120	85	40	50	−30	−2	−29	–	−5	20	–		X	
2N645	120	85	60	75	−30	−2	−29	–	−5	20	–		X	
2N1065	120	85	10	–	−40	−1	−40	−0.5	–	20	80		X	
2N1450	120	85	***		−30	−1	−20	–	−10	20	–		X	

***To switching specification.

NPN

LOW VOLTAGE GERMANIUM ALLOY

TYPE	CHARACTERISTICS (25 ±3°C)												APPLICATION		
TO-5 Case Outline	Max. Diss. (mW) 25°C Ambient	T_j (°C)	f_{ab} (mc)		BV_{CBO} (Vdc)	BV_{EBO} (Vdc)	V_{RT}* (Vdc)	h_{FE}			h_{fe}		SMALL SIGNAL AMPL.	LOW CURRENT SWITCH	HIGH CURRENT SWITCH
		Max. Rated	Min.	Typ.	Min.	Min.	Min.	I_C (mAdc)	Min.	Max.	Min.	Typ.			
2N356	100	85	–	3	+20	+20	+20	+100	20	50				X	
2N356A	150	85	–	3	+30	+20	+30	+100	20	50				X	
2N357	100	85	–	6	+20	+20	+18	+200	20	50					X
2N357A	150	85	–	6	+30	+20	+30	+200	25	75					X
2N358	100	85	–	9	+20	+20	+15	+300	20	50					X
2N358A	150	85	–	9	+30	+20	+25	+300	25	75					X
2N377	150	100	2.5	6	+20	+15	–	+200	20	–					X
2N377A	150	100	2.5	6	+40	+15	–	+200	20	–					X
2N385	150	100	4	6	+25	+15	–	+200	20	–					X
2N385A	150	100	4	6	+40	+15	–	+200	20	–					X
2N388	150	100	5	8	+25	+15	–	+200	30	–					X
2N388A	150	100	5	8	+40	+15	–	+200	30	–					X
2N438	100	85	2.5	–	+30	+25	–	+50	20	–	–	25		X	
2N438A	150	85	2.5	–	+30	+25	–	+50	20	–	–	25		X	
2N439	100	85	5	–	+30	+25	–	+50	30	–	–	35		X	
2N439A	150	85	5	–	+30	+25	–	+50	30	–	–	35		X	
2N440	100	85	10	–	+30	+25	–	+50	40	–	–	65		X	
2N440A	150	85	10	–	+30	+25	–	+50	40	–	–	65		X	
2N444A	150	100	0.5	–	+35	+10	+35	+20	20	40	15	25	X	X	
2N445A	150	100	2	–	+25	+10	+25	+20	40	160	35	70	X	X	
2N446A	150	100	5	–	+25	+10	+20	+20	60	250	60	120	X	X	
2N447A	150	100	9	–	+25	+10	+18	+20	80	300	85	150	X	X	
2N585	150	85	3	5	+25	+20	+24	+20	20	–				X	
2N587	150	85			+40	+40	–	+200	20	–					X
2N634	150	85	5	8	+20	+15	+20	+200	15	–					X
2N635	150	85	10	12	+20	+15	+20	+200	25	–					X
2N636	150	85	15	17	+20	+15	+15	+200	35	–					X
2N679	150	85	2	–	+25	+15	–	+30	20	–				X	
2N1000	150	100	7	–	+40	+40	+40	+100	25	–				X	
2N1012	150	100	3	–	+40	+35	+45	+100	40	–				X	
2N1090	150	85	5	7	+25	+20	+18	+200	20	–					X
2N1091	150	85	10	13	+25	+20	+15	+200	30	–					X
2N1302	150	85	3	4.5	+25	+25	+25	+200	10	–					X
2N1304	150	85	5	8	+25	+25	+20	+200	15	–					X
2N1306	150	85	10	12	+25	+25	+15	+200	20	–					X
2N1308	150	85	15	20	+25	+25	+15	+200	20	–					X
2N1605	150	85	4	12	+25	+12	+24	+20	40	–				X	

PNP & NPN

HIGH VOLTAGE GERMANIUM ALLOY

TYPE	CHARACTERISTICS (25 ±3°C)											APPLICATION		
TO-5 Case Outline	Polarity	Max. Diss. (mW) 25°C Ambient	T_j (°C)	f_{ab} (mc)		BV_{CBO} (Vdc)	BV_{EBO} (Vdc)	V_{RT}* (Vdc)	h_{FE}			SMALL SIGNAL AMPL.	LOW CURRENT SWITCH	HIGH CURRENT SWITCH
			Max. Rated	Min.	Typ.	Min.	Min.	Min.	I_C (mAdc)	Min.	Max.			
CP398	PNP	150	85	–	1	–105	–50	–105	–5	30	–		X	
CP98	PNP	150	85	4	–	–65	–55	–65	–30	30	–		X	
2N398	PNP	50	71	–	–	–105	–50	–105	–5	20	–		X	
2N1310	NPN	120	85	–	1	+90	+20	+90	+5	20	–		X	
2N1311	NPN	120	85	–	1.5	+75	+20	+75	+5	15	–		X	
2N1312	NPN	120	85	–	2	+50	+20	+50	+20	20	–		X	
2N1408	PNP	150	85	–	–	–50	–10	–50	–10	10	–		X	

*V_{RT} (Reach Through Voltage) is measured by the floating emitter potential method.

IN ADDITION TO NORMAL LOT SAMPLING QUALITY CONTROL AND INSPECTION PROCEDURES, CLARE PERFORMS THE FOLLOWING TESTS TO INSURE ABSOLUTE SPECIFICATION COMPLIANCE, HERMETIC SEAL RELIABILITY AND STABILITY OF CHARACTERISTICS.

Clare transistors are 100% tested for all specified minimum or maximum characteristics except dissipation which is tested on a sampling basis. Typical values are checked by sampling procedures.

As a hermetic seal test, Clare transistors are subjected to a 100 ppsi ethylene glycol test for a minimum of eight (8) hours on a 100% basis before final testing.

To ensure stability of characteristics all Clare Transistors are aged for a minimum of 100 hours at $+100 \pm 2^\circ C$ before final testing.

The intent of this brief brochure is to present a broad outline of the transistors currently manufactured by Clare, with indication of important characteristics and general application for each type. An individual detailed specification for each type number is available from C. P. Clare Transistor Corporation or your local C. P. Clare & Company sales office.

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Interesting is the fact that in silicon the ionization coefficient for electrons is larger than for holes, whereas in germanium the opposite is true.

By using more refined methods for measuring the multiplication as a function of bias, Chynoweth[26, 29] discovered that α can be expressed quite simply as an exponential function of the field, E, or

$$\alpha = a \exp\left(-\frac{b}{E}\right) \tag{22}$$

where a and b are constants. Since the above equation is not indicated by Wolff's theory,[24] it is suggested that a fresh theoretical approach is necessary. Quite recently, Maserjian[40] has assumed the above exponential dependence for α to be general and has derived expressions which predict avalanche breakdown for most p-n structures.

In alloyed type diodes, the breakdown voltage, V_B, can be adjusted by control of the resistivity (net impurity density). For a given resistivity, n-type silicon and germanium break down at a higher voltage than p-type. This is due to the fact that in these materials the electron mobility is greater than the hole mobility. In p-material the minority carrier current is by electrons and V_B will not have to be as high to reach avalanche conditions.

Although the avalanche theory is believed to be the predominant process, there is evidence that the Zener mechanism occurs at low voltages and in thin junctions.[22, 31] In silicon diodes with breakdown voltage below about six volts, the breakdown point decreases with rise in temperature. This negative temperature coefficient is consistent with the decrease of the forbidden energy gap with temperature and a consequent lower Zener field.

On the other hand, silicon junctions with breakdown above about six volts have a positive temperature coefficient, because the mobility of the carriers decreases with rise in temperature and higher voltages are required to produce ionization by collision.

Although theory would predict a "sharp" breakdown, in practice one often finds a rounding of the current-voltage characteristics, or what is known as a "soft" breakdown or a "soft knee," particularly at low voltages. The causative factors are not yet completely understood, but they have been ascribed to surface conditions, bulk effects,[32] and thermal effects.[33]

It has also been suggested that the effect of temperature rise due to current flow must be considered in order to explain the shape of the V-I curve in the avalanche region.[34] In addition, the V-I curve itself is not smooth but has a number of discontinuities, which are believed due to the existence of localized breakdown regions, called *microplasmas.*[37]

Apparently, the actual breakdown occurs only in isolated discrete spots, where the current density is obviously very high. The emission of visible light has been observed[35-37] in diodes operating in the avalanche region, and it is believed that the light originates in these spots which may be due to dislocations.[38] The effect is best observed in silicon solar cells, where the junction lies parallel and very close to the surface. Photons with energy as high as 3.2 electron volts (blue light) have been detected.

The spectrum of the light emitted by junctions in which avalanche is taking place indicates that two concurrent mechanisms are probably responsible for the light emission:[38] (a) *de-excitation radiation*—where carriers lose energy (and emit photons with energies up to the threshold value of 2.3 ev), but remain within the same energy band; (b) *recombination radiation*—where highly energetic electrons in the conduction band drop into the valence band and recombine with a hole (emitting photons of energies above 1.1 ev, the energy gap of silicon). Fig. 13 is a schematic representation of the two processes.[39]

Considerable research is still going on pertaining to the fascinating and important phenomenon of reverse breakdown. These efforts are leading to a greater understanding of the behavior of electrons and holes in semiconductors, and to the design and development of improved semiconductor devices.

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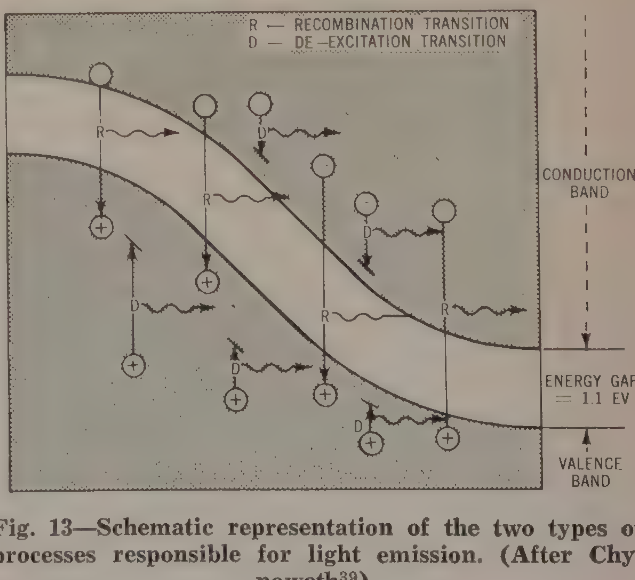

Fig. 13—Schematic representation of the two types of processes responsible for light emission. (After Chynoweth[39]).

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Transistor Switching Analysis

Dr. C. A. MEAD*

Part 2

Diode Recovery. Suppose we connect a junction diode in the circuit shown in *Fig. 6*. If the applied voltage V remains at $+V_1$ for a sufficient time, the current i will reach a steady state value very nearly V_1/R, assuming the forward voltage drop across the diode is small compared with circuit voltages. If now the applied voltage is abruptly changed to $-V_2$, the current is observed to assume a nearly constant value $-V_2/R$ for a *storage time* t_s, after which it decays rapidly to its small steady state reverse value i_s. The explanation for this action is as follows: (5)

At $t = 0$, the excess density of minority carriers near the junction is as shown by the top curve of *Fig. 7*. At a slightly later time, the applied voltage

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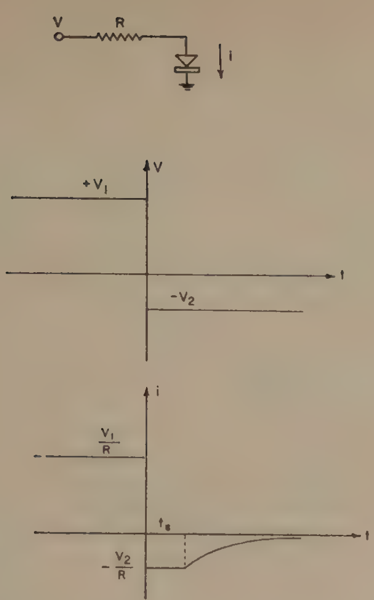


Fig. 6—Recovery of *p-n* diode from step input.

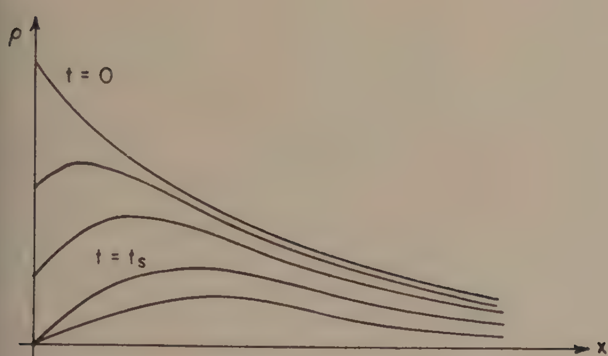


Fig. 7—Excess density distribution in *p-n* diode during recovery.

has reversed, but the *stored carriers* have not had time to recombine or diffuse away. The rate at which they may cross the junction is limited to a maximum reverse current of V_2/R, since a higher value would appreciably forward bias the junction and hence be self-annihilating. However, since the excess density of minority carriers at the junction is greater than zero, the *junction must remain slightly forward biased,* and the voltage across the junction remains small. As long as the junction remains forward biased, the current is determined by the external circuit. In this case, the current during the storage period is very nearly $-V_2/R$. This condition determines the slope of minority carrier density at the junction, which is proportional to the junction current. At the end of the storage time t_s the junction excess density has just reached zero and approaches $-p_n$ as the junction becomes reverse biased. Since the junction excess density is essentially constant (nearly zero) for any reverse bias voltage, the current is no longer affected by the junction voltage but is determined only by the conditions within the semiconductor. Therefore, the *decay time* is characterized by the minority carrier lifetime.

Diode Storage Time Calculation. We may obtain a good estimate of the recovery time from a simple calculation using the one section lumped model of ***Fig. 5c***. Although the results are not nearly as accurate as those which will shortly be obtained for the transistor, they are significant and the method used is typical of all lumped model calculations.

(a) Steady State

Since the diode is forward biased, the voltage across it is small compared with V_1 and we may assume

$$\frac{V_1}{R} \approx I = G\rho_{ss}$$

The voltage across the diode may be found by using the value of ρ_{ss} obtained from this equation and the exponential junction law.

(b) Storage Period

When the applied voltage changes sign, the charge on C cannot change instantaneously, and hence ρ must be continuous. As long as ρ is greater than zero, the diode is forward biased and the voltage across it is small. Hence the current is very nearly $-V_2/R$. To determine the storage time t_s, we find ρ as a function of time assuming the current remains at $-V_2/R$. Then, when ρ becomes very nearly zero, the junction voltage may assume any negative value, and the current approaches zero. To obtain the complete solution for ρ as a function of time, we superpose the steady state value upon the response to a negative current step of magnitude $(V_1 + V_2)/R$, with the result

$$\rho G = \frac{V_1}{R} - \frac{V_1 + V_2}{R}\left(1 - e^{-\omega_h t}\right)$$

At $t = t_s$, the excess density has just reached zero.

$$t_s = \frac{1}{\omega_h} Ln\left(\frac{V_1 + V_2}{V_2}\right) \tag{4}$$

Since there is no longer any charge on C, the current will abruptly stop at $t = t_s$, according to the lumped model. In reality, we know it dies away smoothly. Hence, in this particular case, the lumped model has predicted zero decay time, which may be explained as follows: Since we have used only one lumped section, we have not included the effect of carriers at some distance from the junction, and it is just these carriers which diffuse back to the junction and cause the exponential type decay. With any finite number of lumped sections, the calculated current will exhibit a discontinuity since ρ at the junction approaches zero with a finite $d\rho/dt$, and causes current through the capacitor nearest the junction which must abruptly cease as ρ is clamped at $-p_n$. This lack of accuracy was introduced because of our attempt to use one lumped section to approximate too large a region of

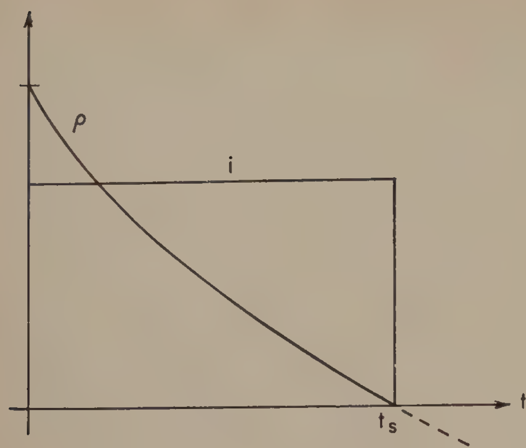


Fig. 8—Recovery characteristic predicted by simple single section model.

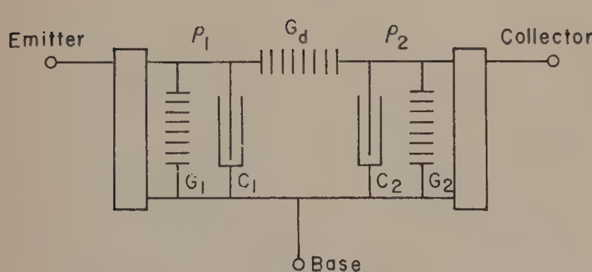


Fig. 9—Complete two-section lumped model of junction transistor with high conductivity collector and emitter regions.

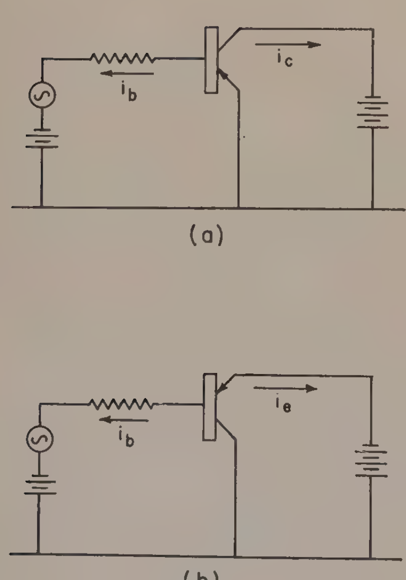


Fig. 10—*p-n-p* transistor in (a) normal and (b) inverse connection.

the semiconductor. The problem is especially bad in fast diodes since the lifetime is made very short and consequently the region to be represented by the lumped model is normally many diffusion lengths. On the other hand, in a transistor the base region is only a very small fraction of a diffusion length and the accuracy obtained is very much better. The justification for using the single section diode model is the ease of determining the element values. In practical design work the choice is usually not between a simple or elegant analysis but rather between a simple analysis or none at all.

Transistor Lumped Model

If the transistor emitter and collector conductivities are high compared to the base conductivity, we may neglect any carrier injection into the emitter and collector and consider only minority carriers in the base region. A two-section model results as shown in *Fig. 9*. In this figure ρ_1 represents the excess density near the emitter, given by

$$\rho_1 = p_n \left(e^{qv_{eb}/kT} - 1\right)$$

where v_{eb} is the emitter-base junction voltage; C_1 and G_1 represent storage and recombination near the emitter, G_d represents diffusion from emitter to collector, ρ_2 is the excess density near the collector, given by

$$\rho_2 = p_n \left(e^{qv_{cb}/kT} - 1\right)$$

where v_{cb} is the collector-base junction voltage; C_2 and G_2 represent storage and recombination near the collector. Both voltages are taken positive when the junction is forward biased.

When the transistor is normally biased as shown in *Fig. 10a*, $\rho_2 = -p_n =$ constant and thus no *a-c* current flows through G_2 or C_2. Therefore, the *a-c* collector current

$$i_c = \rho_1 G_d$$

and the *a-c* base current

$$i_b = \rho_1 (G_1 + sC_1)$$

using the Laplace transform notation. Hence

$$\frac{i_c}{i_b} = \frac{G_d}{G_1 + sC_1} = \frac{G_d/G_1}{1 + s\dfrac{C_1}{G_1}} = \frac{\beta}{1 + \dfrac{s}{\omega_\beta}}$$

where β is the low frequency, short circuit, common emitter, current gain and ω_β is the short circuit, common emitter current gain cutoff frequency. Thus

$$\beta = \frac{G_d}{G_1}$$

$$\omega_\beta = \frac{G_1}{C_1}$$

Since for all reasonable transistors $\beta >> 1$, in all cases of interest $G_d >> G_1$. If the transistor is inverted, i.e., the collector forward biased (acting as an

emitter) and the emitter reverse biased (acting as a collector) as shown in *Fig. 10b*, $\rho_1 = -p_n =$ constant and no *a-c* current flows through G_1 or C_1.

The *a-c* emitter current

$$i_e = \rho_2 G_d$$

and the base current

$$i_b = \rho_2 (G_2 + C_2 s).$$

Hence

$$\frac{i_e}{i_b} = \frac{G_d}{G_2 + C_2 s} = \frac{G_d/G_2}{1 + s\dfrac{C_2}{G_2}} = \frac{\beta_i}{1 + \dfrac{s}{\omega_{\beta i}}}$$

where β_i is the inverted current gain and $\omega_{\beta i}$ is the inverted cutoff frequency. Thus

$$\beta_i = \frac{G_d}{G_2}$$

$$\omega_{\beta i} = \frac{G_2}{C_2}$$

Since β_i is often quite small, we may make no statement with regard to the relative magnitude of G_2 and G_d.

By the four simple measurements of β, β_i, ω_β and $\omega_{\beta i}$, we are able to determine all of the input elements in terms of one (preferably G_d). For many calculations we need not proceed further. However, if we are interested in the voltage across a forward biased junction, we need to determine $p_n G_d$. As in the case of the diode, we cannot determine either p_n or G_d separately by external measurements. Perhaps the best method of determining $p_n G_d$ is to measure the *d-c* emitter-base voltage v_{eb} and the *d-c* collector current I_c in the normal bias connection.

$$I_c = (\rho_1 + \rho_n) G_d = p_n G_d \, e^{qv_{eb}/kT}$$

$$p_n G_d = I_c \, e^{-qv_{eb}/kT} \tag{5}$$

For germanium transistors it is also possible to obtain an approximate value of $p_n G_d$ from a measurement of i_{co}, the collector cutoff current when the emitter is open circuited.

$$i_{co} = p_n \left(G_2 + \frac{G_1 G_d}{G_1 + G_d}\right) = p_n G_d \left(\frac{1}{\beta_i} + \frac{1}{1+\beta}\right)$$

$$\approx p_n G_d \left(\frac{1}{\beta_i} + \frac{1}{\beta}\right)$$

hence

$$p_n G_d \approx \frac{i_{co}\beta\beta_i}{\beta + \beta_i} \tag{6}$$

However, i_{co} is normally composed of a certain amount of surface leakage current and junction depletion layer generation current. Hence the value of $p_n G_d$ obtained in this way may be considerably in error. A measurement of v_{eb} and i_c at a bias current large compared to i_{co} is much to be preferred. In silicon units the i_{co} is largely determined by carrier generation within the junction depletion region and therefore should never be used in the determination of $p_n G_d$.

Transistor Small Signal Performance. We have already used the common emitter current gain characteristic of the transistor in order to determine the values of the lumped model elements. It is of interest to investigate the other aspects of small signal performance as predicted by the lumped model. If the transistor is used in the common base connection and normally biased, the *a-c* collector current

$$i_c = \rho_1 G_d$$

and the *a-c* emitter current

$$i_e = \rho_1 (G_d + G_1 + C_1 s)$$

Therefore

$$\frac{i_c}{i_e} = \frac{G_d}{G_d + G_1 + C_1 s} = \frac{\dfrac{G_d}{G_d + G_1}}{1 + \dfrac{C_1}{G_d + G_1}} = \frac{\alpha}{1 + \dfrac{s}{\omega_\alpha}}$$

where

$$\alpha = \frac{G_d}{G_d + G_1} = \frac{\beta}{1+\beta}$$

$$\omega_\alpha = \frac{G_d + G_1}{C_1} = (1+\beta)\,\omega_\beta$$

Thus the lumped model gives the single time constant approximation for the current gain which is quite accurate for operation well below the alpha cutoff frequency and is commonly used for high frequency calculations. If $\beta >> 1$, we may simplify the last expression as follows:

$$\omega_\alpha \approx \frac{G_d}{C_1} = \beta\omega_\beta$$

In the inverse common base connection similar expressions apply.

$$i_e = \rho_2 G_d$$

$$i_c = \rho_2 (G_d + G_2 + C_2 s)$$

$$\frac{i_e}{i_c} = \frac{G_d}{G_d + G_2 + C_2 s} = \frac{\dfrac{G_d}{G_d + G_2}}{1 + \dfrac{C_2}{G_d + G_2}\,s} = \frac{\alpha_i}{1 + \dfrac{s}{\omega_{\alpha i}}}$$

$$\alpha_i = \frac{G_d}{G_d + G_2} = \frac{\beta_i}{1 + \beta_i}$$

$$\omega_{\alpha i} = \frac{G_d + G_2}{C_1} = (1 + \beta_i)\,\omega_{\beta i}$$

where β_i is not necessarily large compared to unity.

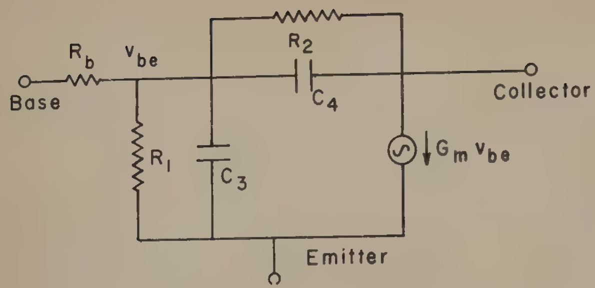


Fig. 11—Transistor small signal equivalent circuit as developed from lumped model.

We may now ask what type of complete common emitter, small signal equivalent circuit results from the lumped model. For small signals, the emitter *a-c* minority carrier density is proportional to the *a-c* emitter-base voltage as shown in equation 3.

$$\rho_1 = \frac{q}{kT} \rho_o v_{be} = K_1 v_{be}$$

The *effective a-c* density at the collector is also proportional to the *a-c* collector-base voltage, due to collector depletion layer widening or Early effect.[(2), (6)]

$$\rho_2 = K_2 v_{cb} \qquad K_2 < < K_1$$

where all quantities of interest are now *a-c* components.

In the common emitter connection, expressions for the base and collector currents become

$$i_c = -\rho_1 G_d + \rho_2 (G_d + G_2 + C_2 s)$$

$$i_b = \rho_1 (G_1 + C_1 s) + \rho_2 (G_2 + C_2 s)$$

Since the emitter voltage is taken as zero, we may rewrite the currents in terms of collector and base voltages.

$$i_c = v_{be} [-K_1 G_d + K_2 (G_d + G_2 + C_2 s)] - K_2 (G_d + G_2 + C_2 s) v_c$$

$$i_b = -v_{be} [K_1 (G_1 + C_1 s) - K_2 (G_2 + C_2 s)] + K_2 (G_2 + C_2 s) v_c$$

These equations correspond to the circuit shown in *Fig. 11.* where

$$R_1 = \frac{1}{K_1 G_1} \qquad R_2 = \frac{1}{K_2 G_2}$$

$$C_3 = K_1 C_1 \qquad C_4 = K_2 C_2$$

$$g_m = K_1 G_d$$

The extrinsic base resistance R_b must be added in series with the base terminal as shown. This circuit is similar to that proposed by Giacoletto[(7)] and widely used for high frequency work. Thus, the lumped model reduces simply to a quite accurate representation in this special case, yet is much more general in that it is useful for all transistor operating conditions.

(To be continued)

Applications Engineering Digests

APPLICATIONS ENGINEERING DIGEST NO. 50

(Circle 198 on Reader Service Card)

Gallium-Arsenide Tunnel Diode Scaler; Philco Corp., Philadelphia, Pa.

Development of high-speed scalers using gallium-arsenide tunnel diodes in series was announced by the Research Division of Philco Corporation. With double-pulse resolution for switching between intermediate states of less than 14 nanoseconds, the device utilizes the characteristic of series-connected tunnel diodes wherein voltage is a multivalued function of current.

Upon initial application of source current, the stack of diodes—treated as a two-terminal device regardless of the number of diodes—maintains its lowest voltage. Each pulse of proper amplitude applied to the input terminal boosts stack voltage to the next higher level. The transistor reset circuit is biased to operate when the highest stack level is reached. See *Figs. 50.1* and *50.2.*

Utilization of GaAs tunnel diodes was encouraged through the devices' intrinsically higher voltage swings, their peak-to-valley ratios of greater than ten to one, and switching times of less than a nanosecond.

With the tunnel-diode scaler, extremely high switching and reset speeds are supplemented by significant reduction in space, weight and power requirements in comparison with beam-switching tubes or cascaded transistor binaries used in like applications.

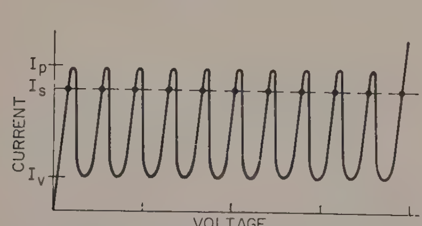


Fig. 50.1—V-I characteristic of tunnel diodes in series.

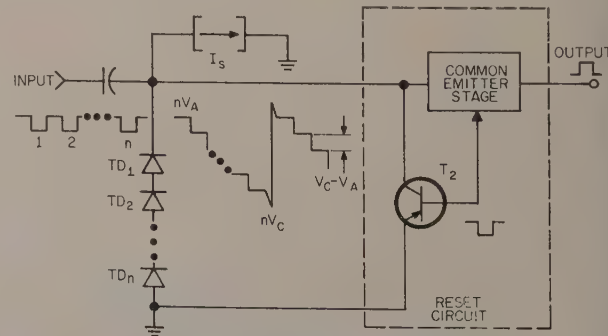


Fig. 50.2—Tunnel diode scaler circuit diagram.

APPLICATIONS ENGINEERING DIGEST NO. 51

Novel Trigistor Circuit Combines Low Level Logic Element and High Level Switch; Solid State Products Inc., Salem, Mass.

The versatility of the Trigistor as a static switching element is graphically illustrated in the circuit of *Fig. 51.1*. In this configuration the Trigistor performs a dual function as a low-level logic element and a high-level static switch. Once it has been turned on, a Trigistor will carry whatever current the load dictates—within its power dissipation ratings—and such a parallel role becomes strikingly practical. Loads such as print-hammers, solenoids, magnetic clutches and brakes, relays, etc. are generally well within the current handling ability of the Trigistor. In this illustration, the Trigistor has two separate loads. Assume, for the moment, that diode D_1 and the high power load are disconnected. The balance of the circuit could represent a portion of a logic circuit, such as a shift register or binary counter stage. When the Trigistor is "on", it carries a collector current of 4 *ma* through R_L. At this level, it can easily be turned off by means of a negative pulse applied to the base terminal. When the Trigistor is "off", its collector voltage is equal to the collector *d-c* supply voltage. With the diode and high power load back in the circuit as shown, if the high power lead is connected to an *a-c* supply bus, D_1 will block whenever the *a-c* voltage is negative under this condition. Trigistor collector current cannot exceed 4 *ma*, and the Trigistor can be turned on and off in accomplishing this function as a logic circuit element. When the *a-c* voltage commences to go positive, if the Trigistor is off, its collector is at the positive *d-c* supply voltage. D_1 will continue to block, provided the *d-c* supply voltage is greater than the peak positive *a-c* voltage. However, if the Trigistor happens to be "on" as a result of logic operations, it and D_1 will conduct current to the high power load. During this period of high current flow, the Trigistor cannot be turned off, so that logic functions and high level output functions must be accomplished on a time-sharing basis. During each negative half cycle, one or hundreds of logic operations can be performed. At the conclusion of a sequence of logic operations, "read-out" is obtained by applying a positive voltage pulse to the bus connected to the power loads.

Pulse power can be used instead of *a-c* to operate high power loads, well up into the ampere region.

(Circle 199 on Reader Service Card)

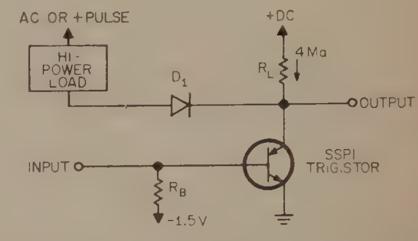


Fig. 51.1—Trigistor dual function circuit.

APPLICATIONS ENGINEERING DIGEST NO. 52

High Peak Operation and Choice of Collector Supply Voltages for Core-Transistor Circuits; Fairchild Semiconductor Corp., Mountain View, Calif. (I. Haas and R. T. Kikoshima)

Circuit Conditions

Shown in *Fig. 52.1* is a typical core-transistor logic circuit. When Core 1 is switched and the voltage across W_0 is such that the transistor Q_1 is turned on, the collector current through W_1 may or may not switch Core 2, depending on the direction of the net *mmf* applied to the core and the state of Core 2 before the application of the pulse in Core 1. In either case, a voltage is developed across W_1 when the transistor is going from "on" to "off" which adds to the collector supply V_{cc}. This voltage is proportional to the reversible flux-mmf characteristics of the core and the time rate of change of collector current.

In some systems of core transistor logic, one transistor may drive many cores. The transient voltages developed in the winding during "turn-off" are additive and it is possible, under this condition, to drive the transistor into the avalanche mode.

Choice of the Collector Supply Voltages

The factors determining the maximum allowable collector supply voltage for a core transistor circuit are:

1. The minimum LV_{CER} as specified by the data sheet.
2. The minimum BV_{CBO}.

The limit established by the minimum LV_{CER} rating is due to the fact that a higher value of V_{cc} would result in a bistable circuit with extremely high dissipation in the avalanche mode. It has been shown that clipping due to LV_{CER} is permissible under certain conditions.

The second limit arises from the condition shown in *Fig. 52.2*. Under this condition, the cores in the collector circuit of an "off" transistor are being switched to the opposite state by the other transistors. In the worst case, all the cores are switched and the voltage across all the windings is NV_{peak} (where V_{peak} is the peak voltage developed across one core winding and N is the total number of cores). This voltage (NV_{peak}) added to the collector supply voltage must be less than BV_{CBO}.

Thus, the collector supply voltage can be as large as LV_{CER} from the point of view of stable operation. However, a lower value might be desirable in applications as described in the preceding paragraph. The worst case design for this application must be such that the collector to emitter voltage is never greater than BV_{CBO}. If this condition is not met, the collector current flowing in transistor Q_1 due to the breakdown will load Q_2, Q_3, etc., and impair the switching times and prevent full switching of the cores.

To demonstrate the operation of the circuit with collector supply voltages approaching LV_{CER}, the circuit in *Fig. 52.3* was investigated.

(Circle 200 on Reader Service Card)

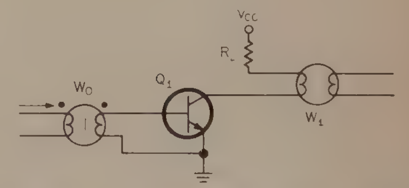


Fig. 52.1—Core-Transistor logic circuit.

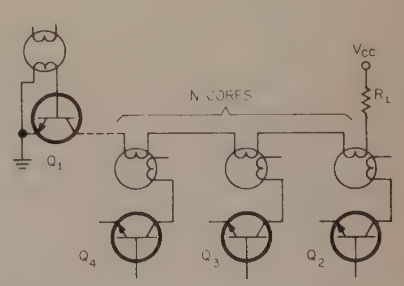


Fig. 52.2—Typical core-transistor logic configuration.

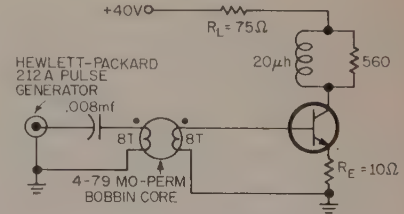


Fig. 52.3—Test circuit.

SEMICONDUCTOR & SOLID-STATE BIBLIOGRAPHY

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHORS
Logic Circuits for an Electronic Switching System	Bell Labs Rec Apr 1960	Discussion and circuitry of a number of logic circuits using diodes and transistors	W. B. Cagle
The Possibilities of the Tecnetron	Br Comm & Elecncs Apr 1960	Investigations are reported of a number of samples of this "unipolar field-effect" transistor. The results obtained, together with measurements and applications, are detailed.	S. Handel
The Tunnel Diode—A Significant New Semiconductor Devices	Br Comm & Elecncs Apr 1960	Article discusses theory of operation, manufacture, characteristics, applications, biasing, and use as an amplifier.	R. W. A. Scarr
Recent Advances in Low-Noise UHF and Microwave Amplifiers	Br Comm & Elecncs Apr 1960	Article discusses principles of operation, variable reactance circuit elements, circuit considerations, noise performance, and applications.	G. O. Chalk
Molecular Electronics—Concepts and Capabilities	Br Comm & Elecncs Apr 1960	Extracts of a talk delivered in Washington are presented. A variety of working subsystems of high reliability are discussed.	S. W. Herwald
The Design of High Frequency Diffused-Base Transistor Amplifiers	Elecl Design News Apr 1960	Description of constructional features, design considerations for video and band pass amplifiers, applications of the amplifier type MADT.	C. D. Simmons P. G. Thomas
Transistor Active Filter Design	Elecl Design News Apr 1960	Design considerations using nomographs are presented for feedback type of a transistor active filter system.	D. Meyer
Transistors for High Reliability	Elecl Mfg Apr 1960	Reliability is discussed in terms of failure. Nature of failure patterns is discussed.	C. H. Zierdt Jr.
Logic—and Switching Circuits	Elecl Mfg Apr 1960	Philosophical and scientific concepts of logic presented at length; includes circuit design and application of Boolean algebra.	A. M. Hilton
Self-Excited Transistor DC-AC Converter Design	Elecnc Design Apr 13 1960	Design considerations include equations, nomographs, and example.	R. Wasserman
Transistor NOT Circuits	Elecnc Equip Eng Apr 1960	Methods of classifying NOT circuits. Typical NOT circuits are analyzed and compared.	R. B. Hurley
Characteristics of Infrared Detectors	Electronics Apr 1 1960	Operating principles and characteristics for thermal, photoconducting, phtovoltaic, and photoelectromagnetic detectors are tabulated.	S. F. Jacobs
Insuring Stability in Time Delay Multivibrators	Electronics Apr 8 1960	Silicon and Zener diodes improve performance of conventional germanium transistor circuit. Timing network is isolated during timing interval.	
Designing TV Tuners with Mesa Transistors	Electronics Apr 8 1960	Complete design procedure for r-f amplifier, mixer, and oscillator stages is given.	H. F. Cooke
Measurement of Diode Switching Characteristics	Electronics Apr 8 1960	Behavior of computer diodes when handling steep-edged, short-duration pulses is investigated.	W. S. Eckess P. G. Ducker
Transistor Amplifier has 100 Megacycle Bandwidth	Electronics Apr 15 1960	Shunt feedback networks around each stage reduce overall gain at low frequencies, trading gain for bandwidth.	J. C. DeBroekert R. M. Scarlett
Linear Circuits Regulate Solid State Inverter	Electronics Apr 15 1960	Total harmonic distortion of 50-watt units is 1% and 400 cps output is regulated to $\pm 0.2\%$. Tuning fork oscillator gives frequency accurate to 0.01%.	R. Wileman
Inductive Element for Solid-State Circuits	Electronics Apr 22 1960	Coilless L-C resonant tank circuit can be constructed with inductive negative-resistance diode. Transistor with open-circuit base connection serves as diode.	M. Schuller W. W. Gartner
Preamplifier Designed for Minimum Power Consumption	Electronics Apr 29 1960	Silicon transistors used in conjunction with high-value circuit resistances allow this three-stage amplifier to operate with a battery drain of less than one milliwatt.	C. D. Todd
Rectifier Modulators—Analysis of Successive Approximations	Elecnc Technology Apr 1960	A general set of equations having been obtained; a method of reducing the complexity of these equations without undue loss of accuracy is postulated.	D. P. Howson
Semiconductors—Fabrication of Silicon Transistors	Elecnc Technology Apr 1960	Pictorial presentation is given of various stages of manufacture.	No Author
Junction Transistor Circuits—Calculation of Temperature Drift	Elecnc Technology Apr 1960	Conclusion of previous installment deals with various circuit configurations. Pertinent equations are presented.	J. J. Ward
A Description of the Tunnel Diode and its Applications	Field Eng Elecnc Dig Apr 1960 RCA	Basic principles of tunnel diodes, includes physical and basic circuit concepts and applications.	J. J. Wentworth
Introduction to Junction Transistors Part II	Field Eng Elecnc Dig Apr 1960 RCA	This article deals with basic characteristic curves and circuitry of the common emitter and common collector configurations.	R. N. Hurst
Electrical Properties of Thin-Film Semiconductors	IBM JL R & D Apr 1960	The theory of the electrical properties of metal films as given by Fuchs and Sondheimer is extended to non-degenerate semiconductors with ellipsoidal energy surfaces.	F. S. Ham D. C. Mattis
Size Effects for Conduction of Thin Bismuth Crystals	IBM JL R & D Apr 1960	Results are reported for high-purity bismuth at 4.2°K for a range of the thicknesses comparable to the electron mean free path.	A. N. Friedman S. H. Koenig
Optical Absorption by Free Carriers in a Semiconductor Containing a Dispersed Colliodal Phase	JL Appd Physics Apr 1960	The optical absorption by free carriers in a semiconductor containing a dispersed colloidal phase is treated taking into account the dipolar diffusion of minority carriers about the particles.	B. R. Gossick
Origin of the "First-Order-Structure" of CP_4-Etched Ge Surfaces	JL Appd Physics Apr 1960	The origin of this structure as observed on micrographs is discussed. It is shown that while etching proceeds, the ending points of some dislocations are reached.	G. Bonfiglioki A. Ferrs A. Monjoni
Piezoresistive Effect in P-Type PbTe	JL Appd Physics Apr 1960	A large positive piezoresistive effect has been observed in p-type PbTe. Certain room temperature coefficients were determined and discussed.	L. E. Hollander T. J. Diesel

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHORS
The Growth of Anodic Oxide Films on Germanium	JL Electrochem Soc Apr 1960	Thick uniform germanium oxide films of controlled thickness have been grown anodically on both n- and p-type germanium.	S. Zwerdling S. Sheff
Lifetime Preservation in Diffused Silicon	JL Electrochem Soc Apr 1960	Minority carrier lifetime in silicon which has been diffused in BCl_3 plus nitrogen at 1100°C may be excess of 100 μsec.	M. Waldner L. Sivo
Anodization of InSB	JL Electrochem Soc Apr 1960	The dependence of the constant current anodization curve on crystallographic face and illumination is reported for monocrystalline InSb.	J. D. Venables R. M. Broudy
Electroluminescence Under Pulsed Square Wave Excitation	JL Electrochem Soc Apr 1960	The slow return of an EL cell to its equilibrium state following field excitation has been studied for a number of phosphors.	R. Zallen W. T. Eriksen H. Ahlburg
Decoupling Capacitors in Grounded-Emitter Amplifier and Oscillator Stages	Mullard Tech Comm Apr 1960	The decoupling capacitors in a conventional circuit are connected to the emitter side of the supply. Distinct advantages result from decoupling to the supply line.	K. Holford
New High Power D. C. Converter Circuits	Mullard Tech Comm Apr 1960	Details of the design and performance are given for a high-power, push-pull, *dc* converter circuit capable of 100W output. Other circuits presented.	J. R. Nowicki
D. C. Amplifier with Balanced Chopper	Mullard Tech Comm Apr 1960	A balanced chopper is designed in which very low direct voltages, of either polarity, may be amplified from low-impedance sources.	S. Gennou H. Kemhadjian
Transistor Monostable Circuits	Mullard Tech Comm Apr 1960	Methods of analysis, and application in two practical circuits. Calculated results and measured values agree.	T. H. Brown W. L. Stephenson
Anharmonic Forces in the GaP Crystal	Phys Review Apr 1 1960	The infrared properties and the thermal expansion of GaP are treated on the basis of a simple model of the anharmonic forces.	D. A. Kleinman
Infrared Lattice Absorption of GaP	Phys Review Apr 1 1960	Transmission and reflectivity measurements of GaP in the wavelength region of 1 to 40 μ have been analyzed to obtain information on the lattice vibrations.	D. A. Kleinman W. G. Spitzer
Space Charge Fields in $BaTi0_3$	Phys Review Apr 1 1960	Experimental observations have been made of (1) hysteresis loops, (2) double loops above the Curie point, (3) Kerr electrooptic effect above the Curie point, (4) capacitance above the Curie point.	S. Triebwasser
Low Temperature Impurity Conduction in n-Type Silicon	Phys Review Apr 15 1960	Hall coefficients and electrical resistivities were measured for specimens containing phosphorous and boron impurities at temperatures down to that of liquid helium.	K. R. Atkins R. Donovan R. H. Walmsley
Internal Field Emussion at Narrow Silicon and Germanium p-n Junctions	Phys Review Apr 15 1960	A detailed study has been made of the reverse characteristics of the junctions with breakdown voltages in the range of about 0.1 to 0.8 volt.	A. G. Chynoweth
Galvanomagnetic Effects in n-Type Silicon	Phys Review Apr 15 1960	The galvanomagnetic effects of n-type silicon has been investigated experimentally and theoretically at 77°K and 300°K.	W. E. Krag
Theory of the Valence Band Structure of Germanium in an External Magnetic Field	Phys Review Apr 15 1960	The energies of the magnetic sub-bands have been calculated as a function of the propagation constant parallel to the external magnetic field.	R. F. Wallis H. J. Bowlden
Properties of p-Type InSb in Pulsed High Electric Fields	Phys Review Apr 15 1960	It is shown that the electron-hole pair creation occurs at electric fields greater than 700 volts/cm. When a sufficient number of pairs are created the Hall coefficient changes from positive to negative.	M. Sterle M. Glicksman
Transistorized Motor Speed Controls For Satellite Tape Recorders	Proc IRE Apr 1960	Discussion of the problems arising in the design of an *a-c* transistorized power supply for low power synchronous motors used in satellite recorders.	M. B. Pickover
Solar Batteries	Proc IRE Apr 1960	Summary of USA-SRDL-developed solar cells to date. Detailed discussion of thermoelectric, thermionic, photovoltaic, and photoemission types of cells—their relative merits, and present and anticipated conversion efficiencies.	A. F. Daniels
A Transistor Bidirectional Limiter	Semiconductor Prods Apr 1960	The excellent saturation characteristics of junction alloy transistors permits design of precision limiters or switches.	H. Schmid
The Magnetic Reset Control of Silicon Control Rectifiers	Semiconductor Prods Apr 1960	The reset scheme of control of self-saturating magnetic amplifiers offers advantages such as fast response and versatility of control signals.	B. Berman
Junction Transistor Measurements and Practical Standards	Semiconductor Prods Apr 1960	Report covers the basic measurements required on most transistors, and specific techniques and circuits for vhf and uhf devices.	B. Reich W. Orloff
Multiple Interval Timers Using Gated Staircase Counters	Semiconductor Prods Apr 1960	An analog-to digital converter using the gated counter principle is discussed.	T. R. Hoffman
Solid State Power Inversion Techniques, Part II	Semiconductor Prods Apr 1960	Example of harmonic commutation is shown with pertinent discussion related thereto and utilizing transistor techniques.	D. A. Paynter B. D. Bedford J. D. Harnden, Jr.
Diffusion and Solubility of Cadmium in Germanium	Sov Phys Sol State Apr 1960	The diffusion of cadmium from the vapor phase and its solubility in germanium are investigated.	V. E. Kosenko
Investigation of "Fast" Surface States of Germanium	Sov Phys Sol State Apr 1960	A pulsed field-effect method was used for studying the topography of "fast" levels at the surface of germanium.	V. G. Litovchenko V. I. Lyashenko
Electrical Properties of Bismuth Alloys	Sov. Phys Sol State Apr 1960	The character of the variations of the mobility of electrons and holes in binary alloys of bismuth is considered.	G. A. Ivanov
Toward the Theory of Elementary Excitations in Atomic Semiconductors	Sov Phys Sol State Apr 1960	A model is considered in which every atom has a saturated valence shell with two electrons. In such a semiconductor, electrons, holes, ortho and paraexcitons may exist.	A. G. Samoilovich S. L. Korolyuk
Certain Electrical Properties of Boro-Silico-Carbides	Sov Phys Sol State Apr 1960	Studies were made of the electrical conductivity and nonlinearity of two boro-silico-carbides, in order to obtain new nonlinear and high resistance linear materials.	V. V. Aleksandrov

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHORS
The Possibility of Creating Ohmic Contact With Silicon by Rubbing The Metal Onto the Semiconductor Using Dry Friction	Sov Phys Sol State Apr 1960	This paper describes a method of producing ohmic recombination contacts with both *n- and p*-type silicon without the necessity of treating the silicon with abrasive materials prior to application of the metal contacts.	I. D. Kirvalidze V. F. Zhukov
Dielectric Polarization of a Number of Complex Compounds	Sov Phys Sol State Apr 1960	The oxides of a number of metals crystallizing with rutile, and certain other structures possess piezoelectric and ferromagnetic properties. This paper investigates dielectric polarization and loss in some of these compounds.	G. A. Emolenskii A. I. Agranovskaya
Calculation of Relaxation Processes of a Phototriode for Low-Intensity Illumination	Sov Phys Sol State Apr 1960	Curves of relaxation of potential difference between emitter and base; collector current is calculated when illuminator is turned on or off.	N. D. Potekhrina
Two Color Infrared Detectors	Tech Abst Bul ASTIA Apr 1 1960 (Uncl) Arlington Hall Stat. Arlington 12, Va.	The intrinsic and extrinsic effect has been investigated. Detector configuration and carrier generation is shown for experimental seven lead cells.	Westinghouse Electric Corp.
Development on Small Germanium Immersed Thermistor Detectors	Tech Abst Bul ASTIA Apr 1 1960 (Uncl) (To obtain see item 1)	Special fixtures for tamping the thermistors into optical immersion with the germanium lens have been fabricated.	R. DeWaard H. Miserocchi
Ultimate Sensitivity and Practical Performance of the Tellurium Photo-conductive Detector	Tech Abst Bul ASTIA Apr 1 1960 (Uncl) (To obtain see item 1)	Calculations have been made for the theoretical noise equivalent power at the peak of spectral sensitivity. Values indicate that this device is an ideal detector.	Willow Run Labs U. of Michigan
Infrared Coating Studies	Tech Abst Bul ASTIA Apr 1 1960 (Uncl) (To obtain see item 1)	Low-and band-pass filters of PbTe/ZnS were fabricated from the absorption edge of PbTe at 3.5 to 11 μ.	L. G. Bartle R. Walsh
Thermoelectricity Quart Rept Nov 59	Tech Abst Bul ASTIA Apr 1 1960 (Uncl) (To obtain see item 1)	Theoretical efficiencies in the temperature range 300-1075°K were increased 25% over the values of a year ago.	Westinghouse Electric Corp.
High Temperature Thermistors	Tech Abst Bul ASTIA Apr 1 1960 (Uncl) (To obtain see item 1)	The quantity of chromic nitrate in the bead mix can be used to control the amount of spread in the resistance distribution of fired beads.	D. W. Brusch
Research on Silicon Carbide Transistors	Tech Abst Bul ASTIA Apr 1 1960 (Uncl) (To obtain see item 1)	The boron-tin-platinum alloy was found to be the most promising one for forming *p-n* junctions in *n*-type silicon carbide.	Westinghouse Electric Corp.
The Fabrication of Silicon Carbide Junctions	Tech Abst Bul ASTIA Apr 1 1960 (Uncl) (To obtain see item 1)	It has been found possible to grow *p-n* junctions in silicon carbide by depositing a single crystal film from the vapor phase onto a silicon carbon seed.	K. M. Hergenrother
Industrial Preparedness Measures, Diffused Semiconductor Devices	Tech Abst Bul ASTIA Apr 1 1960 (Uncl) (To obtain see item 1)	Contents include design engineering and mechanization of devices 12, 2N559 and 2N1094.	B. W. Shugars
Industrial Preparedness Measures On Diffused Semiconductor Devices	Tech Abst Bul ASTIA Apr 1 1960 (Uncl) (To obtain see item 1)	Germanium: Evaluation of all complete MADT environmental and life test results. Silicon: Sample ICBO tests at elevated temperatures are reported. Other pertinent considerations.	J. D. McCotter J. Roschen
Industrial Preparedness Measure on Silicon High Frequency Power Transistors	Tech Abst Bul ASTIA Apr 1 1960 (Uncl) (To obtain see item 1)	Efforts are being made to develop, build, and run a pilot line on a silicon high-frequency power transistor for operation at 10 *mc* with 5W output.	B. Dale A. J. Oszy H. G. Rudenburg
Transistor Temperature Compensating Capacitors	Tech Abst Bul ASTIA Apr 1 1960 (Uncl) (To obtain see item 1)	Cerafil prelminary development models were fabricated. Electrical properties, with characteristics of N150 and N470 types are included in tables and graphs.	R. A. Young
Application of Semiconductor Diodes to Low-Noise Amplifiers, Harmonic Generators, and Fast-Acting TR Switches	Tech Abst Bul ASTIA Apr 1 1960 (Uncl) (To obtain see item 1)	Theoretical analysis and experimental work on silicon tunnel-diode amplifiers with regard to minimum noise temperature, and maximum gain-bandwidth product.	J. C. Greene E. Kraemer et al
R-F and I-F Transformers, High Temperature, Miniaturized, for Transistors (Wide-Band I-F Amplifiers)	Tech Abst Bul ASTIA Apr 1 1960 (Uncl) (To obtain see item 1)	Measurement of all transistor input and output parameters for the 21-, 45- and 60-mc design were completed. Circuit designs at 45 and 60 *mc* were modified.	A. Ossoff
Study of Semiconductor Devices as Functional Replacements for Electron Tube Rectifiers	Tech Abst Bul ASTIA Apr 1 1960 (Uncl) (To obtain see item 1)	Research was conducted to establish appropriate specifications for semiconductor devices used in high voltage rectification applications.	M. D. Burke
Nuclear Radiation Resistant Power Transistors	Tech Abst Bul ASTIA Apr 1 1960 (Uncl) (To obtain see item 1)	Exposure of surface barrier transistors in core tube 36V6 at a power level of 1 megawatt, for periods of 1.8 min and 18 min will provide accumulated dosages of 10^{13} and 10^{14} NVT, respectively.	G. F. Watson
The Diffusion of Boron into Silicon Through Silicon Dioxide for 0.1% Source Strength	Tech Abst Bul ASTIA Apr 1 1960 (Uncl) (To obtain see item 1)	The results for the surface concentration dependence on the diffusion temperature indicate constancy in the range from 1200°C to 1350°C.	J. C. C. Tsai M. O. Thurstan
Application of Silicon Controlled Rectifiers to a D-C Servomotor	Tech Abst Bul ASTIA Apr 1 1960 (Uncl) (To obtain see item 1)	Results are reported of designing, building, and testing a servo system which incorporates silicon controlled rectifiers as the power source of a d-c servomotor.	C. Cantor
Research in the Preparation of Hyperpure Single Crystal Silicon Carbide	Tech Abst Bul ASTIA Apr 1 1960 (Uncl) (To obtain see item 1)	Extensive experiments were carried out on the preparation of single crystal SiC in a graphite tube furnace, after the method of Lely.	D. R. Hamilton
A Study of the Piezoresistive Effects and Preparation Techniques of the Oxide Semiconductor Rutile	Tech Abst Bul ASTIA Apr 1 1960 (Uncl) (To obtain see item 1)	The fourth rank piezoresistive tensor for the D_{4th} tetragonal symmetry of rutile may be expressed in terms of seven piezoresistive coefficients.	L. E. Hollander, Jr. T. J. Diesel G. L. Vick
Research and Development for 70-Ampere High Power Silicon Controlled Rectifier	Tech Abst Bul ASTIA Apr 1 1960 (Uncl) (To obtain see item 1)	Improved electrical characteristics continue to be achieved with the ½ in. diam. junction. Etch cutting of pellets showed improved yield over ultrasonic cutting followed by edge etching.	G. N. Hall R. P. Lyon
Investigation of Methods for Measuring the Equivalent Electrical Parameters of Quartz Crystals	U.S. Govt Res Repts April 15, 1960 LC $12.30 PB138495	A prototype thermistor-bridge power meter for measuring the *r-f* power dissipated in VHF quartz crystals was constructed and tested.	D. W. Robertson S. N. Witt, Jr. W. R. Free
Transistorized Relay Amplifier	U.S. Govt Res Repts April 15 1960 LC $3.30 PB144715	The development of a transistorized relay amplifier of superior performance to vacuum-tube type fo amplifiers is described.	R. A. Bruns J. H. Wilcher

PATENT REVIEW*

Of Semiconductor Devices, Fabrication Techniques and Processes, and Circuits and Applications

Compiled by SIDNEY MARSHALL

The abstracts appearing in this issue cover the inventions relevant to semiconductors from June 10, 1958 to July 15, 1958. In subsequent issues, patents issued from July 15, 1958 to date will be presented in a similar manner. After bringing these abstracts up to date, PATENT REVIEW will appear periodically, the treatment given to each item being more detailed.

une 10, 1958
,838,686 Amplifier For Pulse Type Sig-als—J. P. Eckert, Jr. Assignee: Sperry tand Coropration. A pulse amplifier in /hich the input is controlled so that in esponse to each input the amplifier uilds up to maximum output and re-nains there until cutoff by a clock pulse.

,838,690 Push-Pull Transistor Circuits—. P. Eckert, Jr., H. J. Gray, Jr. Assignee: iperry Rand Corporation. A transistor ircuit that permits multilayer logic to e performed at high repetition rates vith a large number of possible drives.

'une 17, 1958
,839,436 Method and Apparatus for Grow-ng Semiconductor Crystals—B. Corneli-on Assignee: Texas Instruments Incorpo-ated. A method for supplying heat to a emiconductor melt in which a crystal s growing, in order to insure a plane olid liquid interface between the crystal and the melt during the growing opera-ion.

:,839,620 Transistor Amplifier Circuits—'. D. Waldhauer. Assignee: R.C.A. A oush-pull signal amplifier using opposite conductivity type transistors to insure oalanced operation without requiring a oalanced driving source.

:.839,645 Photocell Structure—F. A. Hester Assignee: Clairex Corporation. A radia-ion detecting photocell using a cadmium sulphide crystal mounted in a shock resistant structure that provides the de-vice with protection from thermal shock.

2,839,646 Photocell Structure—F. A. Hester. Assignee: Clairex Corporation. A radiation sensitive photocell structure that provides protection against mechani-cal and thermal shock for the cadmium sulphide embedded therein.

2,839,675 Attenuator Of Noise In Radio Sets—H. Neumann. Assignee: Interna-tional Standard Electric Corporation. A diode noise attenuating circuit coupled to the discriminator circuit of an F.M. receiving set.

2,839,686 Transistor Circuit—H. E. Tomp-kins. Assignee: Burroughs Corp. A trans-istorized multivibrator circuit having low power requirements.

2,839,690 Circuit For Energizing Light Amplifier Devices—B. Kazan. Assignee: R.C.A. Energizing means for an electro-luminescent device wherein the individual materials of the device are selectively energized to provide increased amplifier gain.

2,839,693 Electronic Computer Power Sup-ply Circuits—R. C. Weise Assignee: Burroughs Corporation. A regulated power supply system for a digital com-puter, said system being one which is not dependent upon feedback regulation loops.

June 24, 1958
2,840,489 Process For The Controlled Deposition of Silicon Dihalide Vapors Onto Selected Surfaces—C. P. Kempter, C. Alvarez—Tostado. Assignee: Owens-Illinois Glass Company. Means for de-positing a thin crystallized layer upon a selected surface by erothermically de-composing an unstable lower halide of the elements onto said surface.

2,840,494 Manufacture of Transistors—H. W. Parker. Assignee: None. A manu-facturing method involving the epitaxic deposition of a film of p-type germanium onto a base layer of n-type germanium by bursts of a true metal gas.

2,840,495 Method of Processing Semicon-ductive Materials—R. G. Treuting. Assignee: Bell Telephone Laboratories. A method of producing p-n junctions in silicon and germanium by permanently deforming the n-type portion of a semi-conductor body to introduce acceptor predominance, and thus convert said portion to p-type conductivity.

2,840,496 Semiconductor Device—D. A. Jenny. Assignee: R.C.A. A method for forming an electrode fused to a body of semiconducting cadmium telluride having a p-n junction associated with said body.

2,840,497 Junction Transistors and Process for Producing Them—R. L. Longini. Assignee: Westinghouse Electric Corpora-tion. A double diffusion method for pro-ducing p-n-i-p, or n-p-i-n type junction transistors.

June 24, 1958
2,840,699 Transistor Squelch System Or The Like—F. C. Carpenter, Jr. Assignee: Hoffman Electronics Corporation. A squelch system that may be selectively adjusted for the level of squelch opera-tion desired.

2,840,710 Electrical Crystal Unit—S. L. Levy. Assignee: Sylvania Electric Prod-ucts Inc. A coaxial crystal cartridge with an interval high impedance d-c return path connecting the center conductor and the cartridge shell, said path provid-ing reduction in input signal loss at low microwave frequencies.

2,840,726 Transistor Current Gate— D. J. Hamilton. Assignee: Hughes Aircraft Company. A gate circuit that eliminates a coupling capacitor between the gate and the flip-flop input thereby eliminating a time lag inherent with the use of said capacitor.

2,840,727 Self-Locking Transistor Switch-ing Circuit—W. B. Guggi. Assignee: West-inghouse Electric Corporation. A transist-orized bistable switching circuit.

2,840,728 Non-Saturating Transistor Cir-cuits—G. Haugk, K. K. Kennedy. As-signee: Bell Telephone Laboratories. A transistor bistable multivibrator or flip-flop circuit in which neither transistor can be drven into saturation.

2,840,741 Electroluminescent Cell—W. Lehmann. Assignee: Westinghouse Elec-tric Corporation. An electroluminescent cell in which the phosphor particles are embedded throughout a dielectric in a plurality of substantially straightline particle groupings which are oriented in a direction perpendicular to the elec-trodes.

2,840,770 Semiconductor Device and Method of Manufacture—E. D. Jackson. Assignee: Texas Instruments Incorpo-rated. A semiconductor diode containing a silicon wafer of one conductivity type, a silver wire forming an ohmic contact with said wafer, and a wire connector that produces an opposite type conduc-tivity in the silicon, thus forming a p-n junction therewith.

July 1, 1958
2,804,885 Semiconducting Amplifiers—I. G. Cresswell. Assignee: Marconi Wireless Telegraph Co. Ltd. A method of making a semiconductor amplifier including the steps of forming a grown junction, pro-ducing a visible step at the junction lo-cation by electrolytic etching, and provid-ing an alloy junction to serve as an emit-ter.

2,841,477 Photochemically Activated Gas-eous Etching Method—T. C. Hall Assignee: Pacific Semiconductors Inc. An etching method comprising the steps of immers-ing the body to be etched in an inactive vapor of a photolyzable gas and directing a beam of ultraviolet light upon said body at the portion to be etched.

2,841,503 Film Forming Hydrosols of Barium Titanate, Their Precipitation and A Substrate Coated Therewith—B. Grahm, G. D. Patterson. Assignee: E. I. Dupont de Nemours and Co. A composi-tion containing barium titanate from which thin continuous films of titanate can be applied to substrates.

***Source: Official Gazette of the U. S. Patent Office and Specifications and Drawings of Patents Issued by the U. S. Patent Office.**

2,841,508 Electrical Circuit Elements— R. R. Roup, J. S. Kelby. Assignee: Globe-Union Inc. An electrical circuit element having a body of high dielectric constant material having throughout properties of a semiconductor, and a conducting electrode secured to the surface of said device.

2,841,509 Method of Doping Semiconductive Material—R. V. Hensen, R. A. Laff. Assignee: R.C.A. A method of doping a semiconductive material in its molten phase with an impurity whose boiling point is lower than the melting point of said semiconductor.

2,841,510 Method of Producing P-N Junctions In Semiconductor Materials— S. E. Mayer. Assignee: International Standard Electric Corporation. A method of preventing the unwanted spreading of a deposited significant impurity element over the surface of a crystal.

2,841,650 Telephone Alert System—R. L. Koehler. Assignee. Koiled Kords Inc. A system for alerting a large number of stations over existing telephone circuits without interference with normal telephone operation.

2,841,700 Remote Control Apparatus—F. C. Hallden. Assignee: Hazeltine Research Inc. A remote control apparatus including a transistorized oscillator, an energy storage device coupled to said oscillator, and a transistor *r-f* oscillator.

2,841,702 Semiconductor Automatic Gain Control System—L. E. Barton. Assignee: R.C.A. a transistorized AGC system for a radio receiver, said system providing an effect that may be delayed so that the output signal shows minimum distortion.

2,841,703 Transistor Mixer Circuit With Gain Control—C. C. Bopp, R. W. Bradmiller. Assignee: Avco Manufacturing Corp. In a transistorized receiver, a system of gain control which has a *d-c* power required to control the gain of the *i-f* amplifier circuit.

2,841,712 Transistor Sweep Generators—H. H. Hoge, D. L. Spotten. Assignee: Westinghouse Electric Corporation. A transistor sweep generator which is triggered by the Zener current flowing through a silicon junction diode.

2,841,719 Diode Gate and Its Control Circuit—A. J. Radcliffe Jr. Assignee: International Telephone and Telegraph corporation. A gate used in a telegraph transmission system for removing a carrier from a line and replacing it under signal control.

2,841,730 Single Crystal Electroluminescense—W. W. Piper. Assignee: General Electric Company. An electroluminescent cell comprising a single crystal of an activated phosphor material from the group consisting of zinc sulfide, zinc selenide, cadmium sulfide and cadmium selenide; and a pair of electrodes connected to and at opposite faces of said crystal.

2,841,746 Protective Circuit—D. D. Mawhinney. Assignee: R.C.A. A transistorized current overload protective system for electrical devices.

2,841,749 Selenium Rectifier—G. Eannarino, R. Parsons. Assignee: Sarkes Tarzian Inc. A rectifier comprising an aluminum base plate, a layer of selenium theron, a barrier layer on said selenium, and a counter electrode on said barrier, said barrier being formed by coating the selenium with a dilute solution of an organic substance and an acid of selenium.

2,841,757 Electrical Regulator—C. B. Brake Co. A transistorized current regulating circuit suitable for use in low voltage applications.

July 8, 1959

2,841,860 Semiconductor Devices and Methods—F. Koury. Assignee: Sylvania Electric Products, Inc. A method for growing a semiconductor crystal, cylindrical in shape, have coaxial regions of opposite conductivity, i.e. an inner cylinder of one conductivity type surrounded by an outer cylinder of the opposite conductivity type.

2,842,166 Forming Apparatus for Semiconductor Translating Device Components—F. Wohlman, Jr. Assignee: Hughes Aircraft Company. A method and apparatus which provides support and insures proper alignment and positioning of translating device components relative to forming dies, said method and apparatus thereby permitting the performance of multiple operations on said components.

2,842,466 Method of Making P-N Junction Semiconductor Unit—J. W. Moyer Assignee: General Electric Company. A method for controlling the depth and location of the *p-n* junction relative to the surface of the element, and for controlling the activating element concentration and gradient in the junction region.

2,842,467 Method of Growing Semiconductors—R. W. Landauer, L. P. Hunter. Assignee: International Business Machines. Method and apparatus for maintaining control over the distribution of impurities in semiconducting crystals, forming *p-n* junctions therein, and controlling the specific resistance thereof.

2,842,468 Vapor Deposition of Single Crystals—S. S. Brenner. Assignee: General Electric Company. A method for producing high strength rod-like single crystals of metal by deposition from a metal vapor provided by decomposition of a volatile metal compound at normal atmospheric pressure, and forming said crystal on a substrate at a rate less than that at which imperfectious are introduced.

2,842,623 Transistor Amplifier For Telephone Instrument—P. N. Lehr Assignee: Dictograph Products Company, Incorporated. A transistor amplifier designed to fit into the hand receiver portion of a telephone set and provide supplemental amplification therefore, said amplifier being controlled by an on-off switch which is actuated at the will of the user.

2,842,624 Transistor Amplifier Circuit—R. E. Marsh. Assignee: The Hallicrafters Company. A two stage amplifier utilizing both point contact and junction transistor components.

2,842,682 Reversible Shift Register—G. L. Clapper. Assignee: International Business Machines. A shift register in which the state of each individual trigger is changed only when the condition is required to be changed.

2,842,683 Pulse Generating Circuit—R. J. Simon. Assignee: Carter Motor Company. A square wave pulse generator capable of generating pulses which are, to a great extent, independent of input wave form and which can be made to last over a wide range of periods.

2,842,723 Controllable Asymmetric Electrical Conductor Systems—W. Koch, H. U. Harten, R. Thedrieck. Assignee: Licentia Patent-Verwaltungs G.M.B.H. (Germany). An electrode arrangement for a semiconductor element that minimizes the effect of the size and position of the main electrode on the transformation zone.

2,842,724 Conductor Devices and Method of Making The Same—R. Thedreck. Assignee: Licentia Patent-Verwaltungs G.M.B.H. (Germany). A device in which point electrodes can be secured to the body of the semiconductor, thereby reducing the effects of mechanical vibration and heat expansion upon the operational characteristics of the device.

2,842,725 Directional Conductor Device and Method of Making It—W. Muller. Assignee: Siemens and Halske Aktiengesellschsft (Germany). A point-contact directional conductor surrounded by a mass of non-aqueous cellulose derivative which hardens to form an envelope, or a mass of insulating material such as paraffinil, wax resin, or polysterol.

2,842,744 Balanced Modulator Circuit—R. L. Frank. Assignee: Sperry Rand Corporation. A balanced modulator providing double-balanced full-wave operation with a single-ended output in which there is no transformer loading in the output.

July 15, 1958

2,842,830 Process For The Manufacture of Selenium Rectifier—O. J. Klein. Assignee: International Standard Electric Corporation. A method, which in the manufacture of selenium rectifiers, permits the combination in one plate of the characteristics of plates having either sprayed-on counter-electrodes or melted-on electrodes.

2,842,831 Manufacture of Semiconductor Devices—W. G. Pfann. Assignee: Bell Telephone Laboratories. A method for placing two or more electrodes in close proximity by a masking process which avoids conventional jig type arrangements.

2,842,841 Method of Soldering Leads To Semiconductor Devices—G. L. Schnable, J. Roschen. Assignee: Philco Corporation. A method of soldering leads to semiconductor devices in which a propylene glycol fluxing solution is maintained at a temperature high enough to melt the indium cadmium solder.

2,843,458 Process of Producing Silicon Tetrachloride—R. D. Beattie, L. P. Michel, C. A. Stokes. Assignee: Godfrey L. Cabot, Incorporated. A process for producing silicon tetrachloride from a charge composed of 50-80% silicon carbide, 3-10% carbon, and 17-45% unreduced siliceous matter, by raising the charge temperature to 900° C and treating said charge with chlorine gas.

2,843,511 Semiconductor Devices—J. I. Pankove. Assignee: Radio Corporation of America. A semiconductor body having a surface film separated from the bulk of the body by a rectifying barrier which provides an electric field that repels minority carriers from the surface, thereby minimizing the surface recombination velocity in said device.

CHARACTERISTICS CHARTS OF NEW DIODES and RECTIFIERS

MANUFACTURERS

EG— Allgemeine Elekticitats-Gesellschaft
EI— Associated Electrical Industries, Ltd.
MP— Amperex Electronic Corp.
UD— Audio Devices, Inc.
EN— Bendix Corp.
ER— Berkshire Labs
OG— Bogue Electric Mfg. Co.
OM— Bomac Labs
RA— Bradley Semiconductor Corp.
BS— CBS Electronics
DC— Continental Device Corp.
OL— Columbus Electronics Corp.
TP— Clevite Transistor Products, Inc.
SF— Compagnie Generale de T.S.F.
AL— Dallons Semiconductor
EL— Delco Radio
EVB— English Electric Valve Co., Ltd.
RI— Erie Resistor Corp.
AN— Fansteel Metallurgical Corp.
ERB— Ferranti Ltd.
AH— Gahagan, Inc.
ECB— General Electric Co., Ltd.
E— General Electric Company, Semiconductor Div.
ELC— Canadian General Electric Co.
IC— General Instrument Corp.
TC— General Transistor Corp.
IAFO— Institutet for Halvedarforskning
ISD— Hoffman Semiconductor Division
IITJ— Hitachi Ltd., Mushashi Works
IUG— Hughes Products Division
NRB— International Rectifier Co., Ltd.
NRC— International Rectifier Corp.
RC— International Resistance Co.
TT— International Tel. & Tel. Corp.
EM— Kemtron Electron Products, Inc.
CTF— Laboratoire Central de Telecommunications
ATJ— P. R. Mallory & Co., Inc.
IAL— Matushita Electronics Corp., Takatsuki, Osaka, Japan
IIC— Microwave Associates, Inc.
IIFI— Microfarad
IOT— Motorola, Inc.

MUL— Mullard, Ltd.
NAE— North American Electronics
NPC— Nucleonic Products Co., Inc.
OHM— Ohmite Manufacturing Co.
PHI— Philco Corp. Lansdale Division
PHIN— Philips Gloeilampenfabrieken, Eindhoven, Netherlands
PLEB— The Plessey Co.
PSI— Pacific Semiconductors, Inc.
QSC— International Diode Corp.
RADF— La Radiotechnique, Div. Tubes Electroniques
RAY— Raytheon Company
RCA— Radio Corporation of America, Semiconductor Div.
RHE— Rheem Semiconductor Corp.
ROSG— Dr. Ing. Rudolph Rost
SAR— Sarkes Tarzian, Inc., Rectifier Division
SCN— Semicon, Inc.
SEM— Semi-Elements Inc.
SIE— Siemens & Halske Aktiengesellschaft
SIL— Silicon Transistor Corp.
SOIF— Societe Industrial de Liaisons, Paris 8e, France
SONY— Sony Corp.
SSD— Sperry Semiconductor Division
SSP— Solid State Products, Inc.
STC— Shockley Transistor Corp.
STCB— Standard Telephone & Cables, Ltd.
SYL— Sylvania Electric Products, Inc.
SYN— Syntron Co.
TEX— Texas Research Assoc.
TFKG— Telefunken, Ltd.
TI— Texas Instruments Incorporated
TKD— Tekade, Nurnberg, Germany
TOK— Tokyo Tsushin Kogyo, Ltd.
TRA— Transitron Electronic Corp.
TUN— Tung-Sol Electric, Inc.
TSC— Trans-Sil Corp.
UCI— United Components
USD— United States Dynamics Corp.
USS— U. S. Semiconductor Products, Inc.
VIC— Vickers Inc.
WEC— Western Electric Co.
WEST— Westinghouse Electric Corp.

CHARACTERISTICS CHART of MISCELLANEOUS DIODE TYPES

TYPE NO.	CLASSIFI-CATION	DESCRIPTION	MFR.
1N2771	1	Power Monitoring Diode for UHF	MIC
1N3093	2	X-band Switch for Waveguide Mounting	PHI
1N3096R	2	Gallium Arsenide K-band Mixer Diode	PHI
MA441	2	Ridged Waveguide mounted broad band Video Detector; mica window seal; min. sensitivity-27dbm over 40 to 75 KMC freq. range for 2.5 MC bandwidth and 100 KC min. low freq. cutoff of Video Amplifier.	MIC
MA449A	2	Fixed base cartridge equivalent to 1N21 series of same alphabetical suffix letter with guaranteed performance at 150 deg. C and hermetic solder sealing.	MIC
MA449B	2		MIC
MA449C	2		MIC
MA449D	2		MIC
MA449E	2		MIC
MA452	2	Video Detector interchangable with MA408 Video Detector with additional guarantee of 150 deg. C rating and hermetic sealing.	MIC
MA452A	2		MIC
MA452B	2		MIC
MA453A	2	Fixed base cartridge equivalent to 1N23 series of same alphabetical suffix letter with guaranteed performance at 150 deg. C and hermetic solder sealing.	MIC
MA453B	2		MIC
MA453C	2		MIC
MA454C	2		MIC
MA454D	2		MIC
MA454E	2		MIC
PHG1	4	Sens.100ma/Lumen;dark I-10ua/30V/25 deg. C	NPC
PHG2	4	Sens. 30ma/Lumen;dark I-10ua/30V/25 deg. C	NPC
S11	1,2	Si; S Band; Test freq.-3060Mc;Conv.Loss 6.5db max	ROSG
S15	2	UHF Detector; 5.0ma at 1.0 V	ROSG
S110	2	UHF Detector; 10ma at 1.0 V	ROSG
STC135	Si Stabistor	.64V ± 10 per cent at 1ma If at 25 deg. C; IR-.1ua max at 2 V.	SIL
STC235	Si Stabistor	.70 -.74V at 10ma If at 25 deg. C; IR-.1ua max at 6 V.	SIL
WX809A	8,9	Si; VBO - 50V; PRV- 60V; If -50A max	WEST
WX809B	8,9	Si; VBO -100V; PRV-120V; If -50A max	WEST
WX809C	8,9	Si; VBO -150V; PRV-180V; If -50A max	WEST
WX809D	8,9	Si; VBO -200V; PRV-240V; If -50A max	WEST
WX809E	8,9	Si; VBO -250V; PRV-300V; If -50A max	WEST
WX809F	8,9	Si; VBO -300V; PRV-360V; If -50A max	WEST
WX822A	10	Ip/Iv -8.0; Ip 2.0ma ± 5 per cent Iv -.32ma max	WEST
WX822B	10	Ip/Iv -8.0; Ip 5.0ma ± 3 per cent Iv -.80ma max	WEST

Notations Under Classification

1. Microwave diodes
2. Mixer or detector diodes
3. Varactor diodes
4. Photodiodes
5. Solar Cells
6. Harmonic generator diodes
7. 4-Layer bistable diodes
8. Controlled rectifier
9. PNPN switch
10. Tunnel diode
11. Photoconductive cell

DIODES and RECTIFIERS

TYPE NO.	USE {See Code Below}	MAT	PIV (volts)	MAX. CONT. WORK. VOLT. (volts)	Min. Forward Current @ 25°C I_f (mA)	@ E_f (volts)	MAX. D.C. OUTPUT CURRENT[4] (amps)	@ T (°C)	MAX. FULL LOAD VOLT. DROP[4] (volts)	Max. Rev. Current I_b (uA)	@ E_b (volts)	@ T (°C)	MFR. {See code at start of charts}
D4010	2	Si	400	400	10A	1.5	10	125C		20	400	25C	PLEB
GW106	1	Ge		100	10	.25				5.0	1.5	60	ROSG
GW107	1	Ge		20	100	.75							ROSG
GW108	1	Ge		60	5.0	1.0				75	60	60	ROSG
MP100	2	Si	100		400	1.0	.05	200		75		200	GIC
MP225	2	Si	225		400	1.0	.05	200		75		200	GIC
MP300	2	Si	300		400	1.0	.04	200		75		200	GIC
MP400	2	Si	400		400	1.0	.035	200		75		200	GIC
MP500	2	Si	500		400	1.0	.025	200		75		200	GIC
MP600	2	Si	600		400	1.0	.02	200		75		200	GIC
MS1H	1	Si	60	60	200	1.0	.25	25		50	60	150	AEI
MS2H	1	Si	100	100	200	1.0	.25	25		50	100	150	AEI
MS3H	1	Si	150	150	200	1.0	.25	25		100	150	150	AEI
MS4H	1	Si	200	200	200	1.0	.25	25		100	200	150	AEI
MS5H	1	Si	300	300	200	1.0	.25	25		100	300	150	AEI
OS32	1	Si	15	12	10	1.0	.10	25	1.4	.10	12	25	TKD
OS33	1	Si	60	50	10	1.0	.10	25	1.4	.10	50	25	TKD
OS34	1	Si	110	100	10	1.0	.10	25	1.4	.10	100	25	TKD
OS35	1	Si	160	150	10	1.0	.10	25	1.4	.10	150	25	TKD
OS36	1	Si	350	320	10	1.0	.10	25	1.4	10	320	25	TKD
1M4	3	Si	100	100	400	1.0	.40	25A		.20	100	25A	PLEB
1N2327		Si		1000	400	3.3				1.5	750	25	WEC
1N2328		Si		2000	400	3.3				1.5	1500	25	WEC
1N2791		Si		350	50	1.3				.05	300	25	WEC
1NA1	1	Ge		75	5.0	1.0				500	50	25	KOKJ
1NA2	1	Ge		125	4.0	1.0				600	10	25	KOKJ
1NA3	1	Ge		170	3.0	1.0				500	150	25	KOKJ
1NA4	1	Ge		60	3.0	1.0				800	50	25	KOKJ
1NA5	1	Ge		75	5.0	1.0				100	50	25	KOKJ
1NA6	1	Ge		50	15	1.0				300	30	25	KOKJ
1NA7	1	Ge		120	4.0	1.0				500	100	25	KOKJ
1NA9	1	Ge		35	3.0	1.0				80	10	25	KOKJ
5T3N	2	Si	50	35			50	100A	.50	60ma	50	25	SAR
5T3P	2	Si	50	35			50	100A	.50	60ma	50	25	SAR
10AS	1	Si	100	100	500	1.15	.50	50A		50	100	50A	PLEB
10T3N	2	Si	100	70			50	100A	.50	60ma	100	25	SAR
10T3P	2	Si	100	70			50	100A	.50	60ma	100	25	SAR
12G4	2	Si	1200	1200	400	1.5	.40	25A		20	1200	25A	PLEB
20AS	1	Si	200	200	500	1.15	.50	50A		50	200	50A	PLEB
20T3N	2	Si	200	140			50	100A	.50	60ma	200	25	SAR
20T3P	2	Si	200	140			50	100A	.50	60ma	200	25	SAR
30T3N	2	Si	300	210			50	100A	.50	30ma	300	25	SAR
30T3P	2	Si	300	210			50	100A	.50	30ma	300	25	SAR
40AS	1	Si	400	400	500	1.15	.50	50A		50	400	50A	PLEB
40T3N	2	Si	400	280			50	100A	.50	30ma	400	25	SAR
40T3P	2	Si	400	280			50	100A	.50	30ma	400	25	SAR
60AS	1	Si	600	600	500	1.15	.50	50A		50	600	50A	PLEB
80AS	1	Si	800	800	500	1.15	.50	50A		50	800	50A	PLEB
D1010	2	Si	100	100	10A	1.5	10	125C		20	100	25C	PLEB
D2010	2	Si	200	200	10A	1.5	10	125C		20	200	25C	PLEB

NOTATIONS

Under Use

1. General Purpose
2. Power Rectifier
3. Magnetic Amplifier

Ø Insulated Base

5. Controlled Rectifier
6. Dual Rectifier

△ Direct Tube Replacement

7. Controlled Forward Conductance

Other

4. For half wave resistive load average over 1 cycle

Under Reverse Current

Ø Dynamic

Under Mfr.

6. Available in stack form from that manufacturer

Following any temperature reading these symbols apply

A — Ambient
C — Case
J — Junction
S — Storage
△ — Inlet Temperature of Coolant

Type No.

† — Revised Data

Manufacturers should be contacted for value and test conditions for surge current and maximum peak recurrent current

Under E_f

Ø - at 125°C

SWITCHING DIODES

TYPE NO.	MAT	PIV (volts)	MAX. CONT. REV. WORK. VOLT. (volts)	Min. Forward Current @ 25°C I_f (mA)	@ E_f (volts)	MAX. REVERSE CURRENT @ 25°C I_b (μa)	@ E_b (volts)	Recovery Characteristics: TEST CONDITIONS Fwd. I_f (ma)	to Rev. E_b (volts)	$Z_{rec.}$ (K ohms)	@ time (t) (usec)	MFR. {See code at start of charts}
1S83	Ge	80	80	250	.50	60	80	100	10	500	8.0	HITJ
1S84	Si	200	200	100	1.0	2.0	200					HITJ

VOLTAGE VARIABLE CAPACITOR DIODES

TYPE NO.	CAPACITANCE C @ Eb (uuf)	CAPACITANCE C @ Eb (volts)	PIV	Q @ FREQ. Min. Q	Q @ FREQ. (mc)	MFR.
1S85	14-26	10	20	3.0	240	HITJ
BA410	10	4.0	60	50	50	TKD
GA53694-1	3.55-3.85	0.0	5.5	3.1∅	9000	WEC
GA53694-2	3.80-4.20	0.0	5.5	3.1∅	9000	WEC
GA53694-3	4.15-4.45	0.0	5.5	3.1∅	9000	WEC
GA53694-4	3.55-4.45	0.0	5.5	3.1∅	9000	WEC
GA53695-1	3.55-3.85	0.0	5.5	3.1∅	9000	WEC
GA53695-2	3.80-4.20	0.0	5.5	3.1∅	9000	WEC
GA53695-3	4.15-4.45	0.0	5.5	3.1∅	9000	WEC
GA53695-4	3.55-4.45	0.0	5.5	3.1∅	9000	WEC
MA4253 ∅	1.4max	0.0	6.0	120 KMC cutoff		MIC
MA4280 Δ	.20- .40	6.0	30	20-30 KMC typical		MIC
MA4281 Δ	.40- .80	6.0	30	20-30 KMC typical		MIC
MA4282 Δ	.80-1.6	6.0	30	20-30 KMC typical		MIC
MA4283 Δ	1.2-2.0	6.0	30	20-30 KMC typical		MIC
MA4284 Δ	2.0-3.0	6.0	30	20-30 KMC typical		MIC
MA4285 Δ	3.0-5.0	6.0	30	20-30 KMC typical		MIC
MA4286 Δ	5.0-7.0	6.0	30	20-30 KMC typical		MIC
MA4287 Δ	7.0- 10	6.0	30	20-30 KMC typical		MIC
MA4288 Δ	10- 15	6.0	30	20-30 KMC typical		MIC
MA4289 Δ	15- 20	6.0	30	20-30 KMC typical		MIC
MA4290 Δ	20- 25	6.0	30	20-30 KMC typical		MIC
MA4291 Δ	25- 30	6.0	30	20-30 KMC typical		MIC
MA4292 Δ	30- 35	6.0	30	20-30 KMC typical		MIC
MA4297 Δ	2.0max	6.0	6.0	120 KMC cutoff		MIC
MA4380 †	.20-.40	6.0	30	20-30 KMC typical		MIC
MA4381 †	.40-.80	6.0	30	20-30 KMC typical		MIC
MA4382 †	.80-1.6	6.0	30	20-30 KMC typical		MIC
MA4383 †	1.2-2.0	6.0	30	20-30 KMC typical		MIC
MA4384 †	2.0-3.0	6.0	30	20-30 KMC typical		MIC
MA4385 †	3.0-5.0	6.0	30	20-30 KMC typical		MIC
MA4386 †	5.0-7.0	6.0	30	20-30 KMC typical		MIC
MA4387 †	7.0- 10	6.0	30	20-30 KMC typical		MIC
MA4388 †	10- 15	6.0	30	20-30 KMC typical		MIC

Under Type No.
† - Sub Miniature Glass
∅ - Miniature Pill Varactor
Δ - Double-ended Varactor

The following manufacturers have announced that they have begun supplying the indicated previously registered devices.

CBS ELECTRONICS:
1N482, 1N483, 1N484, 1N485, 1N625, 1N626, 1N627, 1N628, 1N629

CLEVITE TRANSISTOR:
1N645 thru 1N649, 1N676 thru 1N679, 1N681 thru 1N687, 1N689

COLUMBUS ELECTRONICS:
1N253 thru 1N256, 1N538, 1N540, 1N547, 1N1341 thru 1N1348, 1N1730 thru 1N1734, 1N2160, 1N2382, 1N2383

CORNELL-DUBILIER ELECTRIC:
1N1199 thru 1N1206, 1N1341 thru 1N1348, 1N2194 thru 1N2201, 1N2204 thru 1N2211

GENERAL INSTRUMENT:
1N1730, 1N1731, 1N2373, 1N2374, 1N2375, 1N2376, 1N2377, 1N2378, 1N2379, 1N2380, 1N2381, 1N2382, 1N2383, 1N2384, 1N2385

HOFFMAN SEMICONDUCTOR:
1N482 thru 1N488, 1N659, 1N660, 1N661, 1N746 thru 1N759, 1N746A thru 1N759A, 1N821, 1N822, 1N1603 thru 1N1609, 1N1603A thru 1N1609A, 1N1816 thru 1N1836, 1N1816A thru 1N1836A,1N1816R thru 1N1836R,1N1816RA thru 1N1836RA, 1N2008 thru 1N2012, 1N2008A thru 1N2012A, 1N2008R thru 1N2012R,1N2008RA thru 1N2012RA, 1N2043 thru 1N2049, 1N2498 thru 1N2500,1N2498A thru 1N2500A,1N2498R thru 1N2500R,1N2498RA thru 1N2500RA

NUCLEONIC:
1N51, 1N69A, 1N70A, 1N96A, 1N118A, 1N126A, 1N139, 1N140, 1N145, 1N198, 1N273, 1N276, 1N277, 1N279, 1N281, 1N282, 1N294, 1N295, 1N297, 1N309, 1N452, 1N476, 1N477, 1N541, 1N542, 1N616, 1N617, 1N636, 1N805

PHILCO:
1N26AMR, 1N26AR, 1N26BMR, 1N26BR, 1N26CMR, 1N26CR, 1N26MR, 1N26R, 1N78AMR, 1N78AR, 1N78BMR, 1N78BR, 1N78CMR, 1N78CR, 1N78DMR, 1N78DR, 1N78MR, 1N78R

SEMI-ELEMENTS:
1N35, 1N36, 1N39B, 1N40, 1N52A, 1N60A, 1N63A, 1N65, 1N66A, 1N71, 1N87, 1N87A, 1N89, 1N96, 1N96A, 1N97A, 1N98, 1N98A, 1N99A, 1N100, 1N100A, 1N108, 1N117A, 1N118, 1N118A, 1N127A, 1N128A, 1N137A, 1N139, 1N140, 1N141, 1N143, 1N144, 1N145, 1N209 thru 1N214, 1N270, 1N273, 1N276, 1N279, 1N281, 1N287, 1N288 thru 1N292, 1N294A, 1N297A, 1N298, 1N298A, 1N302, 1N304, 1N305, 1N307, 1N309, 1N310, 1N312, 1N313, 1N434, 1N447 thru 1N450, 1N452 thru 1N455, 1N463, 1N497 thru 1N500, 1N542, 1N634, 1N773, 1N773A, 1N774, 1N774A, 1N775, 1N776, 1N805

SILICON TRANSISTOR:
1N645, 1N646, 1N647, 1N708, 1N709, 1N710, 1N711, 1N712, 1N713, 1N714, 1N715, 1N716, 1N717, 1N718, 1N719, 1N720

TEKADE:
1N34, 1N48, 1N52, 1N54, 1N57, 1N60, 1N63, 1N64, 1N65, 1N67, 1N70, 1N81, 1N87, 1N295, 1N636

TUNG-SOL ELECTRIC:
1N253 thru 1N256, 1N538, 1N540, 1N547, 1N1183 thru 1N1198, 1N1291, 1N1292, 1N1294, 1N1296, 1N1396, 1N1397, 1N1398, 1N1399, 1N1400, 1N1401, 1N1402

PART 2
NEW DIODES and RECTIFIERS

TYPE NO.	USE (See Code Below)	MAT	PIV	MAX. CONT. WORK. VOLT.	Min. Forward Current @ 25°C		MAX. D.C. OUTPUT CURRENT[4] @ T (°C)		MAX. FULL LOAD VOLT. DROP[4]	Max. Rev. Current			MFR. (See code at start of charts)
					I_f @	E_f				I_b @	E_b @	T	
			(volts)	(volts)	(mA)	(volts)	(amps)		(volts)	(uA)	(volts)	(°C)	
1N35	1	Ge	75	60	20	1.0				500	50		OHM
1N135	1	Ge	75	60	5.0	1.0				800	50		OHM
1N175	1	Ge	125	100	5.0	1.0				50	50		OHM
1N947	1	Si	600		400	1.0				275-4		25	WEC
1T26	1	Ge	40	35	8.0	1.0	.05	25A		80	10	25A	SONY
4B11N	2	Si	50	35	35A	1.2	35	140C	1.7	10ma	35	140C	FAN-6
4B11P	2	Si	50	35	35A	1.2	35	140C	1.7	10ma	35	140C	FAN-6
4B12N	2	Si	100	71	35A	1.2	35	140C	1.7	10ma	71	140C	FAN-6
4B12P	2	Si	100	71	35A	1.2	35	140C	1.7	10ma	71	140C	FAN-6
4B13N	2	Si	150	106	35A	1.2	35	140C	1.7	10ma	106	140C	FAN-6
4B13P	2	Si	150	106	35A	1.2	35	140C	1.7	10ma	106	140C	FAN-6
4B14N	2	Si	200	142	35A	1.2	35	140C	1.7	10ma	142	140C	FAN-6
4B14P	2	Si	200	142	35A	1.2	35	140C	1.7	10ma	142	140C	FAN-6
4B15N	2	Si	250	177	35A	1.2	35	140C	1.7	10ma	177	140C	FAN-6
4B15P	2	Si	250	177	35A	1.2	35	140C	1.7	10ma	177	140C	FAN-6
4B16N	2	Si	300	212	35A	1.2	35	140C	1.7	10ma	212	140C	FAN-6
4B16P	2	Si	300	212	35A	1.2	35	140C	1.7	10ma	212	140C	FAN-6
4B17N	2	Si	350	247	35A	1.2	35	140C	1.7	10ma	247	140C	FAN-6
4B17P	2	Si	350	247	35A	1.2	35	140C	1.7	10ma	247	140C	FAN-6
4B18N	2	Si	400	284	35A	1.2	35	140C	1.7	10ma	284	140C	FAN-6
4B18P	2	Si	400	284	35A	1.2	35	140C	1.7	10ma	284	140C	FAN-6
6B11N	2	Si	50	35	20A	1.2	20	150C	1.5	5000	35	150-5	FAN-6
6B11P	2	Si	50	35	20A	1.2	20	150C	1.5	5000	35	150-5	FAN-6
6B12N	2	Si	100	71	20A	1.2	20	150C	1.5	5000	71	150-5	FAN-6
6B12P	2	Si	100	71	20A	1.2	20	150C	1.5	5000	71	150-5	FAN-6
6B13N	2	Si	150	106	20A	1.2	20	150C	1.5	5000	106	150-5	FAN-6
6B13P	2	Si	150	106	20A	1.2	20	150C	1.5	5000	106	150-5	FAN-6
6B14N	2	Si	200	142	20A	1.2	20	150C	1.5	5000	142	150-5	FAN-6
6B14P	2	Si	200	142	20A	1.2	20	150C	1.5	5000	142	150-5	FAN-6
6B15N	2	Si	250	177	20A	1.2	20	150C	1.5	5000	177	150-5	FAN-6
6B15P	2	Si	250	177	20A	1.2	20	150C	1.5	5000	177	150-5	FAN-6
6B16N	2	Si	300	212	20A	1.2	20	150C	1.5	5000	212	150-5	FAN-6
6B16P	2	Si	300	212	20A	1.2	20	150C	1.5	5000	212	150-5	FAN-6
6B17N	2	Si	350	247	20A	1.2	20	150C	1.5	5000	247	150-5	FAN-6
6B17P	2	Si	350	247	20A	1.2	20	150C	1.5	5000	247	150-5	FAN-6
6B18N	2	Si	400	284	20A	1.2	20	150C	1.5	5000	284	150-5	FAN-6
6B18P	2	Si	400	284	20A	1.2	20	150C	1.5	5000	284	150-5	FAN-6
7B11N	1	Si	50	35	12A	1.2	12	150C	1.5	10ma	35	150-5	FAN-6
7B11P	1	Si	50	35	12A	1.2	12	150C	1.5	10ma	35	150-5	FAN-6
7B12N	1	Si	100	71	12A	1.2	12	150C	1.5	10ma	71	150-5	FAN-6
7B12P	1	Si	100	71	12A	1.2	12	150C	1.5	10ma	71	150-5	FAN-6
7B13N	1	Si	150	106	12A	1.2	12	150C	1.5	10ma	106	150-5	FAN-6
7B13P	1	Si	150	106	12A	1.2	12	150C	1.5	10ma	106	150-5	FAN-6
7B14N	1	Si	200	142	12A	1.2	12	150C	1.5	10ma	142	150-5	FAN-6
7B14P	1	Si	200	142	12A	1.2	12	150C	1.5	10ma	142	150-5	FAN-6
7B15N	1	Si	250	177	12A	1.2	12	150C	1.5	10ma	177	150-5	FAN-6
7B15P	1	Si	250	177	12A	1.2	12	150C	1.5	10ma	177	150-5	FAN-6
7B16N	1	Si	300	212	12A	1.2	12	150C	1.5	10ma	212	150-5	FAN-6
7B16P	1	Si	300	212	12A	1.2	12	150C	1.5	10ma	212	150-5	FAN-6
7B17N	1	Si	350	247	12A	1.2	12	150C	1.5	10ma	247	150-5	FAN-6
7B17P	1	Si	350	247	12A	1.2	12	150C	1.5	10ma	247	150-5	FAN-6
7B18N	1	Si	400	284	12A	1.2	12	150C	1.5	10ma	284	150-5	FAN-6
7B18P	1	Si	400	284	12A	1.2	12	150C	1.5	10ma	284	150-5	FAN-6
8B11N	2	Si	50	35	70A	1.2	70	150C	1.2	15ma	35	150-5	FAN-6
8B11P	2	Si	50	35	70A	1.2	70	150C	1.2	15ma	35	150-5	FAN-6
8B12N	2	Si	100	71	70A	1.2	70	150C	1.2	15ma	71	150-5	FAN-6
8B12P	2	Si	100	71	70A	1.2	70	150C	1.2	15ma	71	150-5	FAN-6
8B13N	2	Si	150	106	70A	1.2	70	150C	1.2	15ma	106	150-5	FAN-6
8B13P	2	Si	150	106	70A	1.2	70	150C	1.2	15ma	106	150-5	FAN-6
8B14N	2	Si	200	142	70A	1.2	70	150C	1.2	15ma	142	150-5	FAN-6
8B14P	2	Si	200	142	70A	1.2	70	150C	1.2	15ma	142	150-5	FAN-6
8B15N	2	Si	250	177	70A	1.2	70	150C	1.2	15ma	177	150-5	FAN-6
8B15P	2	Si	250	177	70A	1.2	70	150C	1.2	15ma	177	150-5	FAN-6
8B16N	2	Si	300	212	70A	1.2	70	150C	1.2	15ma	212	150-5	FAN-6
8B16P	2	Si	300	212	70A	1.2	70	150C	1.2	15ma	212	150-5	FAN-6
8B17N	2	Si	350	247	70A	1.2	70	150C	1.2	15ma	247	150-5	FAN-6
8B17P	2	Si	350	247	70A	1.2	70	150C	1.2	15ma	247	150-5	FAN-6
8B18N	2	Si	400	284	70A	1.2	70	150C	1.2	15ma	284	150-5	FAN-6
8B18P	2	Si	400	284	70A	1.2	70	150C	1.2	15ma	284	150-5	FAN-6
9A11N	1	Si	50	35	5000	1.2	5.0	150C	1.5	1000	35	150-5	FAN-6
9A11P	1	Si	50	35	5000	1.2	5.0	150C	1.5	1000	35	150-5	FAN-6
9A12N	1	Si	100	71	5000	1.2	5.0	150C	1.5	1000	71	150-5	FAN-6
9A12P	1	Si	100	71	5000	1.2	5.0	150C	1.5	1000	71	150-5	FAN-6
9A13N	1	Si	150	106	5000	1.2	5.0	150C	1.5	1000	106	150-5	FAN-6
9A13P	1	Si	150	106	5000	1.2	5.0	150C	1.5	1000	106	150-5	FAN-6

TYPE NO.	USE (See Code Below)	MAT	PIV (volts)	MAX. CONT. WORK. VOLT. (volts)	Min. Forward Current @ 25°C I_f (mA)	@ E_f (volts)	MAX. D.C. OUTPUT CURRENT[4] (amps)	@ T (°C)	MAX. FULL LOAD VOLT. DROP[4] (volts)	Max. Rev. Current I_b (uA)	@ E_b (volts)	@ T (°C)	MFR. (See code at start of charts)
9A14N	1	Si	200	142	5000	1.2	5.0	150C	1.5	1000	142	150-5	FAN-6
9A14P	1	Si	200	142	5000	1.2	5.0	150C	1.5	1000	142	150-5	FAN-6
9A15N	1	Si	250	177	5000	1.2	5.0	150C	1.5	1000	177	150-5	FAN-6
9A15P	1	Si	250	177	5000	1.2	5.0	150C	1.5	1000	177	150-5	FAN-6
9A16N	1	Si	300	212	5000	1.2	5.0	150C	1.5	1000	212	150-5	FAN-6
9A16P	1	Si	300	212	5000	1.2	5.0	150C	1.5	1000	212	150-5	FAN-6
9A17N	1	Si	350	247	5000	1.2	5.0	150C	1.5	1000	247	150-5	FAN-6
9A17P	1	Si	350	247	5000	1.2	5.0	150C	1.5	1000	247	150-5	FAN-6
9A18N	1	Si	400	284	5000	1.2	5.0	150C	1.5	1000	284	150-5	FAN-6
9A18P	1	Si	400	284	5000	1.2	5.0	150C	1.5	1000	284	150-5	FAN-6
BC101	2	Si	50	50			1.0	25C	1.5	5.0	50	25C	BRA
BC102	2	Si	100	100			1.0	25C	1.5	5.0	100	25C	BRA
BC103	2	Si	200	200			1.0	25C	1.5	5.0	200	25C	BRA
BC104	2	Si	300	300			1.0	25C	1.5	5.0	300	25C	BRA
BC105	2	Si	400	400			1.0	25C	1.5	5.0	400	25C	BRA
BC106	2	Si	500	500			1.0	25C	1.5	5.0	500	25C	BRA
BC107	2	Si	600	600			1.0	25C	1.5	5.0	600	25C	BRA
BC108	2	Si	700	700			1.0	25C	1.5	5.0	700	25C	BRA
BC109	2	Si	800	800			1.0	25C	1.5	5.0	800	25C	BRA
BC203	2	Si	200	200			.75	25C	2.8	5.0	200	25C	BRA
BC204	2	Si	300	300			.75	25C	2.8	5.0	300	25C	BRA
BC205	2	Si	400	400			.75	25C	2.8	5.0	400	25C	BRA
BC206	2	Si	500	500			.75	25C	2.8	5.0	500	25C	BRA
BC207	2	Si	600	600			.75	25C	2.8	5.0	600	25C	BRA
BC208	2	Si	700	700			.75	25C	2.8	5.0	700	25C	BRA
BC209	2	Si	800	800			.75	25C	2.8	5.0	800	25C	BRA
BC305	2	Si	400	400			.50	25C	3.6	5.0	400	25C	BRA
BC307	2	Si	600	600			.50	25C	3.6	5.0	600	25C	BRA
BC309	2	Si	800	800			.50	25C	3.6	5.0	800	25C	BRA
BC1001	2	Si	900	900			1.0	25C	1.5	5.0	900	25C	BRA
BC1002	2	Si	1000	1000			1.0	25C	1.5	5.0	1000	25C	BRA
BC2001	2	Si	900	900			.75	25C	2.8	5.0	900	25C	BRA
BC2002	2	Si	1000	1000			.75	25C	2.8	5.0	1000	25C	BRA
BC2003	2	Si	1100	1100			.75	25C	2.8	5.0	1100	25C	BRA
BC2004	2	Si	1200	1200			.75	25C	2.8	5.0	1200	25C	BRA
BC2007	2	Si	1500	1500			.75	25C	2.8	5.0	1500	25C	BRA
BC2010	2	Si	1800	1800			.75	25C	2.8	5.0	1800	25C	BRA
BC2012	2	Si	2000	2000			.75	25C	2.8	5.0	2000	25C	BRA
BC3002	2	Si	1000	1000			.50	25C	3.6	5.0	1000	25C	BRA
BC3004	2	Si	1200	1200			.50	25C	3.6	5.0	1200	25C	BRA
BC3007	2	Si	1500	1500			.50	25C	3.6	5.0	1500	25C	BRA
BC3010	2	Si	1800	1800			.50	25C	3.6	5.0	1800	25C	BRA
BC3012	2	Si	2000	2000			.50	25C	3.6	5.0	2000	25C	BRA
BC3015	2	Si	2250	2250			.50	25C	3.6	5.0	2250	25C	BRA
BC3017	2	Si	2500	2500			.50	25C	3.6	5.0	2500	25C	BRA
BC3020	2	Si	2750	2750			.50	25C	3.6	5.0	2750	25C	BRA
BC3022	2	Si	3000	3000			.50	25C	3.6	5.0	3000	25C	BRA
GA53691	1	Si	35		10	1.0							WEC
SD005	1	Si	50	50	250	1.0	.25	25A		100	50	100	SSD
SD010	1	Si	100	100	250	1.0	.25	25A		100	100	100	SSD
SD015	1	Si	150	150	250	1.0	.25	25A		100	150	100	SSD
SD020	1	Si	200	200	250	1.0	.25	25A		100	200	100	SSD
SD025	1	Si	250	250	250	1.0	.25	25A		100	250	100	SSD
SD030	1	Si	300	300	250	1.0	.25	25A		100	300	100	SSD
SD035	1	Si	350	350	250	1.0	.25	25A		100	350	100	SSD
SD040	1	Si	400	400	250	1.0	.25	25A		100	400	100	SSD
SD405	1	Si	50	50	400	1.5	.40	25A		500	50	150	SSD
SD410	1	Si	100	100	400	1.5	.40	25A		500	100	150	SSD
SD415	1	Si	150	150	400	1.5	.40	25A		500	150	150	SSD
SD420	1	Si	200	200	400	1.5	.40	25A		500	200	150	SSD
SD425	1	Si	250	250	400	1.5	.40	25A		500	250	150	SSD
SD430	1	Si	300	300	400	1.5	.40	25A		500	300	150	SSD
SD435	1	Si	350	350	400	1.5	.40	25A		500	350	150	SSD
SD440	1	Si	400	400	400	1.5	.40	25A		500	400	150	SSD

NOTATIONS

Under Use

1. General Purpose
2. Power Rectifier
3. Magnetic Amplifier

Ø Insulated Base

5. Controlled Rectifier
6. Dual Rectifier

△ Direct Tube Replacement

7. Controlled Forward Conductance

Other

4. For half wave resistive load average over 1 cycle

Under Reverse Current

Ø Dynamic

Under Mfr.

6. Available in stack form from that manufacturer

Following any temperature reading these symbols apply

A — Ambient
C — Case
J — Junction
S — Storage
△ — Inlet Temperature of Coolant

Type No.

† — Revised Data

Manufacturers should be contacted for value and test condition for surge current and maximum peak recurrent current

Under E_f

Ø - at 125°C

Market News . . .

Prices

Philco has available a gallium arsenide mixer diode designed for 24 kmc. Type 1N3096R K-band diode is priced at $75 each in quantities of 1-9 units. Matched pairs, type IN3096m are priced at $187.50 per pair. The firms Lansdale division has also reduced prices on both their Micro Alloy and Micro Alloy Diffused-Base transistors. Two units — the MAT 2N293 switch and the MADT 2N501 switching device — were cut to $3.45 and $4.90, respectively, in quantities of 1,000 or more. The 2N393 had cost $4.15 each and the 2N501, $6.75 each.

The other five MAT transistors, with old and new prices, include:

2N393 (Mil)	$4.45	$3.75
2N1122	5.05	4.35
2N1122A	6.35	5.35
2N1411	4.30	3.40
2N1427	4.35	3.60

The other six transistors, all MADTs, with old and new prices, include:

2N499	$3.30	$2.65
2N499 (Mil)	3.50	2.80
2N501A (Mil)	8.40	6.10
2N502	3.50	2.50
2N502A (Mil)	4.40	3.10
2N504	2.90	2.30

Raytheon Co. has reduced prices on 24 silicon transistors. Switching transistors 2N333-38 and 2N1386-90 were reduced 18-58%. Subminiature types 2N745-51 were reduced 10-54%. Five of their power units were also reduced 18-32%.

Hughes Aircraft Company's semiconductor division has announced a price reduction of 10 to 55 per cent on its complete line of diodes, transistors and rectifiers. These include a reduction of 55 per cent on many of the division's silicon general purpose diodes, a 25 per cent drop in silicon mesa *p-n-p* high switching transistors, and similar reductions in germanium diodes, silicon rectifiers, silicon *p-n-p* fused junction transistors, silicon *p-n-p* high frequency transistors, and zener voltage regulator diodes.

Texas Instruments Incorporated has available four new gallium arsenide tunnel diodes. These are priced as follows:

	1-99	100-999
1N650	$27.30	$21
1N651	39.00	30
1N652	18.20	14
1N653	11.70	9

Sylvania has announced prices on three of its germanium tunnel diodes. Their D4115 with a minimum oscillation frequency of 2kmc, is listed at $17.50 each; D4115 minimum of 3kmc, $27.50 each; and D4115B minimum of 4kmc $37.50 each.

Semiconductor division of Sarkes-Tarzian, Inc. has started supply production quantities of its line of silicon zener voltage regulators. Prices on 10% tolerance units for the 0.25w are from $3.80 to $5.55 each; for the lw unit from $3.95 to $5.80 each and for the 10w unit from $7.90 to $8.60 each.

Minneapolis-Honeywell Regulator Co. has reduced prices up to 39% on seven of its H-5 line of germanium power transistors and 20% on four of its tetrode transistors.

Hoffman Electronics Corp. is now marketing solar cell assemblies. Type 2H5B which provides 32 ma is priced at $16 each. Type H5C which provides 42ma is listed at $22.40 each. The firm has also made available a new line of silicon controlled rectifiers. Encased in TO-5 transistor packages, the units consist of five *n-p-n-p* types. HCR-30N through HCR-200N and seven *p-n-p-n* types, HCR-30P through HCR 400P. Prices for the *n-p-n-p* devices depending on voltage types, range from $8.40 to $22.50 each in quantities of 1-99, and from $5.60 to $15 each in quantities from 100-999. The *p-n-p-n* units are priced from $5.60 to $60 each (1-99) and $3.70 to $40 each (100-999).

Electronic Chemicals Division of Merck and Co., Inc. has reduced prices on their electronic grade silicon from 6 to 28 per cent. Their new price list follows:

FLOAT ZONE REFINED SINGLE CRYSTAL

Type N Resistivity Ranges (Ohm Cm)	Type P Resistivity Ranges (Ohm Cm)	Price/Gram
below 0.099	below 0.099	*
0.1 to 1.0	0.1 to 1.0	1.59
1 to 50	1 to 100	1.39
51 to 100	101 to 200	1.59
101 to 300	201 to 300	1.79
above 300	301 to 1000	*
	1000 Min.	2.96

* Prices in these ranges are quoted depending on specifications.

POLYCRYSTALLINE SILICON

Polycrystalline Billets . . . High purity silicon with a maximum boron level of 1 part in 6 billion.	0.44/Gm

Sales

According to the EIA, transistor manufacturers, during the first half of 1960, recorded a 67 per cent gain over 1959 in unit sales at the factory. June business increased over May by more than 1,300,000 transistors.

The following tables show EIA's monthly and year-to-date statistics:

	Units	Units
June	10,392,412	$27,341,733
May	9,046,237	24,146,373
April	9,891,236	23,198,576
March	12,021,506	28,700,129
February	9,527,662	24,831,570
January	9,606,630	24,714,580
Year-to-date '60	60,485,683	152,932,961
Year-to-date '59	36,098,026	99,813,775

According to the U. S. Dept. of Commerce, Japanese output of electronic products in the first quarter of this year totaled $281.1 million, up 53 per cent from the same period of 1959. Semiconductors registered the greatest percentage increase in production of any electronic product group for the first quarter 1960 compared with the first quarter 1959, up 67 per cent to $19.1 million, closely followed by electron tubes, up 63 per cent to $44.5 million. The ouput of radio receivers with three or more transistors in the first quarter of this year was valued at $38.0 million, 95 per cent higher than in the first quarter of 1959.

Financial

Philco has reported an increase in sales of 7.2% but a decrease in earnings of 19% for the first six months in 1960. First half sales were $194,280,000 and earnings $1,941,000 compared to sales of $181,345,000 and earnings of $2,386,000 for the same period last year. Earnings were 43¢ per common share compared to 54¢ last year. Transistor sales, however, more than doubled despite Defense Department cutbacks in the 2nd quarter.

Sperry Rand has reported a net profit for the quarter ending June 30 of $5,410,579 equal to 19¢ per share. This is a decrease of almost 40% from the $9,014,87 or 31¢ a share for the same period last year. Sales of products and services increased 6.2% to $291,761,602 from $274,694,309 from last year.

Texas Instruments Inc., has reported that profits for the first half of 1960 were up 26% over last year. Earnings were $7,921,000 equal to $2.00 per common share as compared with $6,305,000 or $1.62 per share for the same period last year. Sales for the first six months were $116,051,000 up from $94,199,000 for the first half of 1959.

Suppliers

Jupiter Electronics Inc., New York has introduced a 3-pin transistor holder using a spring-loaded collet locking mechanism. Designated as model T3T, it is priced at $2.89 each and is available in 9 EIA colors.

High Purity Metals, Hacksensack, N. J. has developed an automated process for reclaiming high-grade germanium scrap. Their new process is being used to reclaim either on a toll basis or by supplying on a scrap-credit basis intrinsic polychystalline germanium.

Pellon Corp., New York has developed semiconductor polishing discs said to cut costs and polishing cycle time in the fabrication of molectronic circuits and epitaxial crystals. The cloths are available in packages of one-dozen from 4½" to 12" diameter with prices from $3.50 to $1 depending upon the style. These are being marketed by Geoscience Instruments Corp., N.Y.C.

Dow Corning Corp. is now marketing polycrystalline silicon in rod form at $330 per pound under 100 pound lots. The rods are available in diameters up to 26mm and in lengths up to 17.7 inches. The firm is adding a 44,000 square foot addition to their two months old plant in Hemlock, Mich. The new addition is expected to be in operation by January 1961.

Distributors

Standard Rectifier Corp. has appointed Hudson Radio & TV Corp., New York as an authorized industrial distributor.

Schweber Electronics, components distributor of Mineola, L. I., N. Y. has announced the relocation of its Eastern Sales Office. The new headquarters will be in the Perpetual Building, 8710 Georgia Avenue, Silver Spring, Maryland.

New Firm

Tyco, Inc., is planning to locate in a Boston suburb. The new firm will initially produce existing products such as silicon transistors, silicon controlled rectifiers, tunnel diodes and other high frequency semiconductor devices.

Industry News . . .

CONFERENCE CALENDAR

he Following November 1960 Meetings Are Scheduled:

ov. 4-5 Communications Symposium, Queen Elizabeth Hotel, Montreal, Canada. Sponsored by Montreal Section IRE. For Information: C. F. Ripp, Box 802 Station B, Montreal, P.Q.

ov. 14-16 Mid-American Electronics Conference (MAECON), Hotel Muehlebach, Kansas City, Mo. Sponsored by Kansas City Section IRE. For Information: J. E. Austin, Bendix Corp., 95th & Troost, Kansas City, Mo.

ov. 15-16 PG on Production Tech. 4th Annual Conference, Boston Mass. Sponsored by PGPT & NEREM. For Information: C. W. Watt, Raytheon Co., Waltham 54, Mass.

Nov. 14-17 Conference on Magnetism & Magnetic Materials, New Yorker Hotel, New York City. Sponsored by AIEE, AIP, ONR, IRE, AIME, PGMT & T. For Information: A. M. Clogston & R. C. Fletcher, Bell Telephone Labs, Murray Hill, N. J.

Nov. 15-17 Northeast Electronic Research & Engineering Meeting (NEREM) Commonwealth Armory & Sheraton Plaza Hotel, Boston, Mass.

Nov. 27-28 American Physical Society Meeting, Hotel Windermere, Chicago. Sponsored by AIP.

Nov. 27-Dec. 2 ASME Annual Meeting, Statler & Sheraton-Atlantic Hotel, New York City.

RESEARCH AND DEVELOPMENT

The semiconductor division of Hughes Aircraft Company is building a laboratory production line for a parametric mode transistor that operates at ultra-high and microwave frequency ranges in the circuit recently invented and demonstrated at Lenkurt Electric Co., Inc., a subsidiary of General Telephone & Electronics. The Hughes transistor was designed to operate in the parametric mode at a frequency range two to five times higher than what was considered the absolute frequency limit of any commercial transistor. It has produced nearly 4 kilomegacycles at 10 per cent efficiency when tested in the UHF and microwave mixer-oscillator circuit invented last fall by Dr. Vladimir W. Vodicka of Lenkurt's Advanced Development group. The transistor's designer, Hughes' physicist Rainier Zuleeg, predicts even higher frequency ranges in the microwave region — eventually up to 10 kilomegacycles while still retaining a minimum efficiency of 10 per cent.

Dr. Vodicka believes his discovery will lead to simplifying circuitry in communication equipment and possibly in electronic computers. Both emphasize that the circuit and transistor are still in developmental stages. "But even in this early stage," the scientists declare, "we are convinced these developments have unusually promising possibilities."

Studies underway at Bell Telephone Laboratories on one of the most efficient thermoelectric materials yet developed were discussed recently at the International Conference on Semiconductors at Prague, Czechoslovakia. The compound is composed of the elements silver, antimony, and tellurium. Its chemical designation is silver antimony telluride ($AgSbTe_2$). The search for improved materials at Bell Laboratories centered on ternary intermetallic semiconductor compounds, many of which have a cubic crystal structure similar to sodium chloride. The desired crystal formation is somewhat disordered and contains heavy atoms such as tellurium. Many compounds, and alloys of compounds, some with as many as seven elements, have been produced and studied. The best of these discovered to date has been silver antimony telluride. This material is now being widely studied in laboratories in this country and around the world.

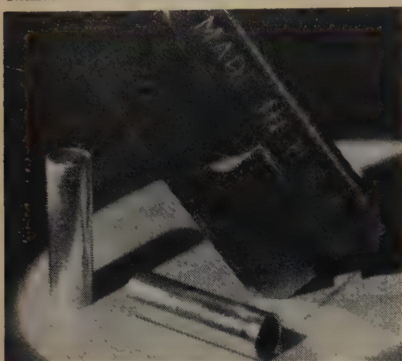
The material possesses a very low thermal conductivity, necessary in order to maintain a temperature differential between two ends of a device. Its thermoelectric figure of merit, "Z", has recently been measured by scientists at Radio Corporation of America, and is reported to be about $1.75 \times 10^{-3}/°C$ over a range of 200° to 500°C, which is the best yet observed for p-type thermoelements in this range. In the studies reported, silver antimony telluride was described as having a disordered cubic structure, exhibiting a thermal conductivity as low as 0.0064 watts/cm°C at room temperature, only one one-hundredth that of germanium. While the material is always thermoelectrically p-type, its Hall effect is p-type in some specimens, and n-type in others, even when taken from a single ingot.

Drs. Raymond Wolfe (l.) and Jack H. Wernick, both of Bell Telephone Laboratories, check the mounting on a sample of silver antimony telluride before measuring its Hall coefficient. The sample was cut from a zone-refined crystal of the new thermoelectric material similar to the one in Dr. Wernick's hand.

Aeroprojects Incorporated of West Chester, Pa., recently was granted two basic United States patents on ultrasonic welding; they contain method and equipment claims on both ultrasonic spot-type and ultrasonic seam welding.

New Products

Gallium Arsenide Mixer Diode



Philco Corporation's Lansdale Division has introduced a gallium arsenide microwave mixer diode. The new device is specified for 24,000 mc (k-band) first detector operation and is housed in a coaxial package identical to that used for existing silicon k-band diodes. It features a band-gap energy value of 1.40 electron volts and is capable of high temperature operation considerably in excess of the upper limit capabilities of germanium and silicon components. Higher mobility values achieved by the 1N3096R permit greatly increased sensitivity at 24 kMc. The diode exhibits an overall noise figure of 10.5 db. Changes in noise figure of less than 2 db have been noted for temperature ranges of 300° C.

Circle 111 on Reader Service Card

KMC Oscilloscope

Type 519 is the new Tektronix KMC Oscilloscope—a calibrated, high-speed, laboratory instrument designed for observation, measurement, and photographic recording of wide-band phenomena. A 2 x 6 cm viewing area, coupled with 24 kv accelerating potential affords bright displays with excellent definition. Performance features include: passband from d-c to beyond 1000 mc, risetime of 0.35 nsec, sensitivity of 10 v/cm, linear sweeps to 2 nsec/cm, and sweep delay to 35 nsec. For clear display of: Recovery time of fast diodes, fast diode turn-on, avalanche transistors, tunnel diode wave forms, switching transistors, high-speed circuit analysis, etc.

Circle 116 on Reader Service Card

Epoxy Tubing

Epoxy tubing for component encapsulation of capacitors, resistors, semiconductor devices, delay lines, coils, plug in components, etc., is available from Resdel Corp. Thirty-five sizes between .180″ and 1.312″ O.D.; larger sizes available. Supplied with any wall thickness, .015″ and heavier. Produced in 57″ lengths, precision cut to special lengths. Available in compounds and colors. Materials for high heat distortion, self extinguishing, low coefficient of expansion and other characteristics.

Circle 90 on Reader Service Card

Mesa Transistor Series

A new germanium mesa transistor series for communications applications was announced recently by Texas Instruments Incorporated, featuring low noise figures with f (max) in excess of 1000 mc. 2N1405, 2N1406 and 2N1407 feature exceptional gain characteristics for transistors which operate in the VHF/UHF range. Each of these devices are production tested to assure maximum noise figures of 6db, 8db and 10db respectively at 200 mc. The series has excellent emitter-base diode characteristics which make them useful as mixers, well into the UHF range.

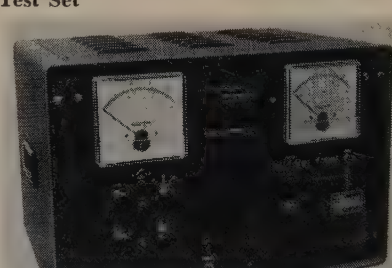
Circle 112 on Reader Service Card

High Purity Silicon

High purity silicon in polycrystalline rod form is now being produced by Dow Corning. Above Grade I in quality, these rods are especially suitable for zone refining to the single crystal silicon used in power rectifiers, transistors, diodes, and other semiconductor devices. By vacuum zone refining, polycrystalline rod can be converted to single crystal silicon having typical resistivity greater than 1000 ohm-centimeter, minority carrier lifetime greater than 400 microseconds.

Circle 119 on Reader Service Card

Test Set



Dynatran Model 1818 100 Megacycle & Gain Bandwidth Test Set provides direct readings of the 100 megacycle gain of transistors. It also provides direct readings of the gain bandwidth product up to 1000 megacycles. This instrument is complete in itself and requires no auxiliary equipment. It is power line operated and uses no batteries.

Circle 127 on Reader Service Card

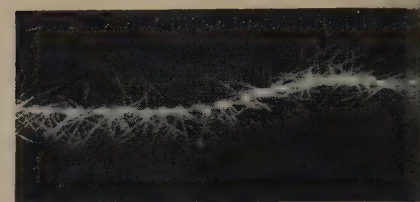
Gold Alloy Preforms

Gold 99.99+% pure alloyed with antimony, silicon, germanium, gallium or tin and fabricated into spheres, foil, washers, discs, rectangles and squares for semiconductor devices is now available from Alpha Metals, Inc. Dimensions of these materials are as follows: Spheres range from .005″ with tolerances as close as .0001″. Discs from .005″ up. Foil from .0005″ thin. Rectangles from .040″ to .015″. Squares .020″. Washers from .020″ i.d. and a land of .005″.

Circle 121 on Reader Service Card

Fuse Material

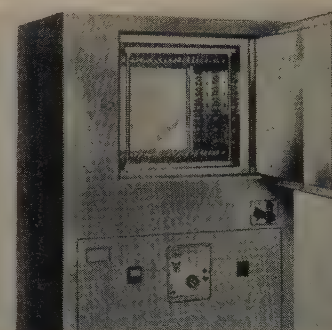
The manufacture of specially processed Pyroforic Products, now known as PYROFUZE, has been announced by Pyrofuze Corp., a newly-formed affiliate of Sigmund Cohn Corp. PYROFUZE material is available in the form of wire and ribbon, made in production quantities. The wire is a bimetallic product that disintegrates with explosive violence at 600° C without support of oxygen. It is recommended for explosively operated devices, electrically detonated. Also obtainable in experimental quantities are PYROFUZE sheet and stamped preforms.



Photograph taken a few milliseconds after ignition of 6″ length of .003″ diameter PYROFUZE Wire.

Circle 115 on Reader Service Card

Aging Ovens



Blue M mechanical convection, horizontal airflow aging ovens with saturable power reactor control and built-in range-lock overtemperature protection are ideal for accelerated aging at controlled temperatures. Straight-line control derived from control system without contacts, switches, moving parts or auxiliary mechanisms to wear, burn or arc; there are no transient voltages due to arcing contacts. Temperature Range: 35°C. to 180°C. (356°F.)

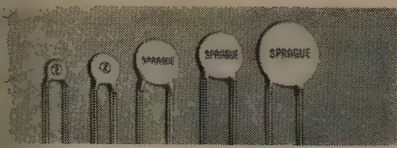
Circle 129 on Reader Service Card

1000 Watt Ultrasonic Cleaner

Industrial users of ultrasonic cleaning can maintain constant maximum efficiency in even the biggest cleaning operations with Powertron Ultrasonic Corporation's Autosonic Series 1000 ultrasonic cleaners. The new units require no operator attention or tuning, and maintain optimum cleaning performance by means of feedback transducer which electronically compensates for all varying load conditions. Multiple units may be combined in modular installations to give up to ten kilowatt operation.

Circle 134 on Reader Service Card

;ramic Disc Capacitors

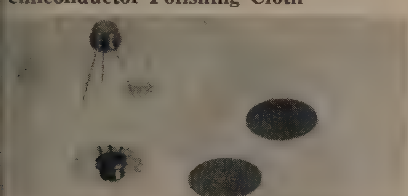


Designed to meet the small size, high ,pacitance demands of low voltage cir- ;uitry, Hypercon Ceramic Disc Capaci- .rs offer capacitance values usually railable only with electrolytic capaci- .rs, yet these new units are only a action of the size of comparable electro- tic capacitors. They are the result of ı extensive research program by the prague Electric Company to develop iniature ceramic capacitors especially iited for bypass and coupling applica- ons in transistor circuitry. They have ccellent stability with no loss in capaci- nce above room temperature. Operat- g Temperature Range: —55° C to +85° C.
Circle 113 on Reader Service Card

iffused Alloy Power Transistors

Bendix 2N1651, 2N1652 and 2N1653 is a ries of Diffused Alloy Power DAP tran- stors designed for efficient high current vitching at high frequencies. A diffused ıse region provides very low input resis- ınce and high cutoff frequency (typical- 2.0 Mc.) while maintaining high break- own voltage (Vce-120 Vdc absolute ıaximum rating for the 2N1653). The igh frequency, high voltage character- tics are particularly suitable for use as switch. In addition the flat beta param- ter makes it ideally suited as an ampli- er.
Circle 122 on Reader Service Card

emiconductor Polishing Cloth



A new polishing cloth has been devel- ped by the Pellon Corporation and Geo- cience Instruments, Inc. Especially uited for polishing semiconductor sur- aces, it will produce the finishes required ɔr fabricating mesa and planar devices, ıoletronic circuits, epitaxial crystals and recision infrared optics. Adhesive acked Pellon Polishing Discs are avail- ble in a variety of sizes and are pro- uced under ultra clean conditions to void contamination.
Circle 123 on Reader Service Card

ilicon Mesa Transistor

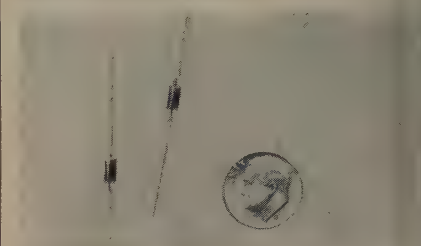
Microbloc RT697M, a higher powered, mproved 2N697 transistor in a new solid- lesign, microminiature package, has been announced by Rheem Semiconductor Corporation. It has a guaranteed welded hermetic seal and occupies about 1/7th the volume of the standard 2N697, is .063 inches flat, .211 inches in diameter and weighs only ¼ gram. Electrically, it not only meets all the specifications of the 2N697 but has 3 watts power dissipation, (50% more), resulting in cooler running junction for wider safety margins and higher reliability.
Circle 118 on Reader Service Card

Industrial Laminates

A phenolic varnish producing a flam retardant, high electrical grade laminat with excellent cold punching properti has been announced by Monsanto Chem ical Company's Plastics Division. Desig nated Resinox 495, the paper-based in dustrial laminates impregnated with th new phenolic varnish meet the electrica physical and mechanical requirements o NEMA standards and Underwriters' Lab oratories test for flame resistance. Th are especially recommended as coppe clad laminates for electronic compute and military applications.

Circle 128 on Reader Service Card

Silicon Rectifier Diodes



A series of hermetically sealed silico rectifier diodes, featuring high stabilit extreme versatility, miniature design and rugged construction has been an nounced by Diodes, Inc. Designated a DI-52, DI-54, DI-56, DI-58, and DI-51 these diodes have peak inverse voltag ratings of 200, 400, 600, 800, and 1,000 V respectively. All five types handle 75 ma at 25°C and 500 ma at 100°C. 100 output extends beyond 100 kc, with th 3-db point at 250 kc. Ambient tempera ture range is −65°C to +150°C.

Circle 124 on Reader Service Card

High Purity Metals

The Research Chemicals Division c Nuclear Corporation of America has an nounced a new grade of rare earth metal representing higher purities. Designate (h.p.), they conform to the followin specifications: Oxygen—less than 0.1% Tantalum—less than 0.01%, Other rar earths—less than 0.1%, Iron—less tha 0.03%. It is anticipated that these meta will prove of great interest for those i the electronics industry and associate industries where ever-increasing puriti are of paramount importance.

Circle 126 on Reader Service Card

Vacuum Pumping System

High Vacuum Equipment Corporatio announces a new line of completely self contained portable high-speed vacuu pumping carts or mobile evaporatio units with 2-, 3-, 4- or 6-inch diffusio pumps. The completely packaged system can be equipped with pumping por adapters for matching a wide range o vacuum furnaces, evaporation environ mental chambers, or many other labora tory vacuum units and components.

Circle 93 on Reader Service Card

Transistor Holder

A new 3-pin transistor holder, Mode T3T, designed to eliminate holding fail ures of transistors undergoing shock, vi bration and environmental tests has bee introduced by Jupiter Electronics, Inc Constructed of heat resistant materials they have been used to hold transistor undergoing environmental tests to 260°C Other applicatoins include their use i equipment designed for the aging, relia bility testing, and automatic checkout o transistors.

Circle 125 on Reader Service Card

rystal Oscillators

A new line of precision transistorized ystal oscillators especially suited for plication in communications systems, rborne electronic equipment, and uided missiles is available from the Instrial Systems division of Hughes Airaft Company. They contain a silicon ansistor oscillator circuit, and are in the equency range of 1 mc to 5 mc, with a -hour frequency stability of $\pm 2x10^{-7}$.

Circle 120 on Reader Service Card

entrifugation For Semiconductors

Reliability tests for diodes, transistors, apacitors and other semiconductors are ow furthered by spinning them at high ntrifugal speeds. Lourdes Instrument orp. announces development of special ntrifuge rotors with cavities cut to conrm to exact contours of the components be tested. Relative centrifugal forces om 10,000 to 25,000 times gravity are ecured, subjecting components to some f the effects encountered in space travel. he rotors can be designed to accommoate almost all semiconductor compoents.

Circle 132 on Reader Service Card

ransistor Test Equipment

Herbert Industries is offering a line of ansistor test equipment in modular orm, designed for component testing by anual, semi-automatic, and automatic rocedures. The test modules contain asic test circuits. Various read out pans containing standard or special indiators are available for use with the test odules. The equipment is fully unitized nd compatible with present testing needs nd future test equipment expansion prorams.

Circle 131 on Reader Service Card

ilicon Controlled Rectifiers

The Semiconductor Division of Hoffan Electronics Corporation recently anounced the availability of a line of complementary" silicon controlled rectiers. The line consists of 5 *n-p-n-p* types which utilize negative gate current trigering; and 7 *p-n-p-n* types which are riggered by positive gate currents. All nits are rated at 1 amp, average rectified orward current, and 1.4 amp, direct current, at plus 80° C. Operating and storage emperature range for all types is from 65° C to +150° C. Maximum junction emperature is +150° C.

Circle 110 on Reader Service Card

lew Slicing Method

A new method of slicing friable mateials with the inside diameter of a donuthaped cutting wheel has been introduced y The DoALL Company. The I/D Microlicer will cut scrap loss in half and ield many more wafers per ingot. Cutting wheels only .006- to 010-in. thick re used and kerf loss will be reduced 0 to 50% for semiconductor manufacurers, according to the company. The licer is part of the company's new model MTA-70 slicing machine. This is one of our new Microtom-atic models designed or increased productivity.

Circle 79 on Reader Service Card

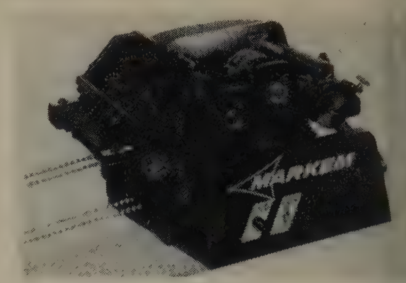
(*continued on page 62*)

NEW SERVICE NOW AVAILABLE

SEMICONDUCTOR PRODUCTS is making a new source of information available to all firms interested in being kept up to date on materials or equipment for producing semiconductor devices. If you wish to receive all new literature on silicon, germanium, chemicals, machinery, or other such materials, circle #99 on the reader-service card. Your name will be placed on a special list which will be forwarded to all such suppliers. As these suppliers have news available in their field, you'll be notified by them immediately. This service is restricted to firms manufacturing semiconductor devices or firms contemplating entering into production within 120 days.

New Products *(from page 59)*

Marking Machine



A new machine for marking axial lea components with text and polarity mark ings in accordance with JAN specifica tions has been announced by Marke Machine Company. At production speed of 2,600 and more per hour, Model 14 prints trademark, polarity symbol an band, and desired code markings on d odes, capacitors, resistors and other axi lead components with curved or irregul surfaces. With optional features, this ma chine will also handle units with heade leads. Visibility of imprints on cryst components can be increased by printin on a background color, using a combina tion of two Model 146A machines, on feeding automatically into the other.

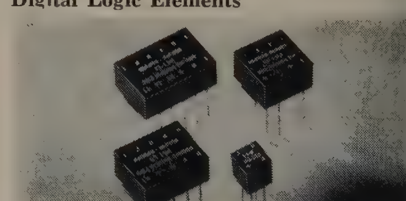
Circle 105 on Reader Service Card

Audio Frequency Transistors

A series of general purpose *p-n-p* ger manium alloy transistors which meet th mechanical and environmental require ments of MIL-S-19500B and associate specifications have been announced b Sylvania Electric Products Inc. The ne hermetically sealed devices (Type 2N650, 2N651, and 2N652) are designed fo both amplifier and switching application in the audio frequency range. They hav a maximum collector to base voltage o 45 volts, maximum collector to emitte of 25 volts, maximum collector curren of 250 ma, and a maximum junction tem perature of 100° C.

Circle 133 on Reader Service Card

Digital Logic Elements



The Data Systems Division of Harman Kardon has introduced a line of Logi Elements representing a significant ad vance in digital building blocks. The fol lowing are some of the characteristic featured in these ruggedized package Operating temperature range of −65° C t +100° C; high density for car mountin applications; leads have 0.2″ grid spacing typical unit weighs 6 grams; fewe coupling circuits; no wasted components circuit simplicity; all units use 12 vol and/or +12 volt power supplies.

Circle 117 on Reader Service Card

Switching Silicon Glass Diodes

A new series of high current silico glass diodes was announced by Silico Transistor Corp. Types 1N690 throug 1N693, are capable of switching .5A cur rent and are ideal for use in high curren pulse circuits, diode logic circuits as wel as for high speed computer switching pulse clamping, gating and blocking Temperature range: −65°C to +150°C Power dissipation 25°C: 400 mW max.

Circle 104 on Reader Service Card

ansistorized Power Supply

Anders Electric Products Inc. Model 002A contains four regulated power pplies which are isolated and may be nnected in many combinations for mputers or transistorized equipment in e laboratory. Available voltages: 1 to volts d-c for each output in current nges of 2, 4, and 8 amperes. Regulation better than 0.1% for line and load. pple is better than I mv rms. Remote nsing and short circuit proof. Input nge from 105 to 125 V, 50 to 400 cps, phase. Operation up to 50°C ambient.
Circle 100 on Reader Service Card

lm-Forming Dielectric

Cyanocel, a new film-forming and oldable dielectric, a dielectric constant 12.5, has been developed by American yanamid Company.

Electroluminescence and microminia-re capacitors are two known applica-ons for this new material. Clear, trans-rent films as thin as 0.1 mil or as thick 5 mils or more have been cast from lutions of highly cyanoethylated cel-lose in a number of organic solvents or lvent mixtures. At a frequency of 60 cles, the 2-mil films have a dielectric nstant of 10-15 and a dissipation factor 0.010-0.025.
Circle 77 on Reader Service Card

licon Diodes and Rectifiers

A new line of silicon diodes, rectifiers, ener diodes and double anode diodes ith a capacity of 500 mW and in a case easuring only 3/16" diameter x 1/16" ick has been announced by the Elec-on Division of Controls Company of merica. The new "Sildisc" diodes fea-re a double-cup design with maximum eat dissipation, and can be mounted a variety of printed circuit applications pening complete new assembly methods, cording to company engineers.
Circle 76 on Reader Service Card

tatic Contactors

A new line of Static Contactors is an-ounced by Electronic Specialty Co. elay Div. These devices are available SPST, DPST, 3PST and 4PST models ith output of 10 amperes at 115 VAC nd input of 28 V @ 125 MA. Engineering esigns are also available with output naracteristics from dry circuit to 20 mperes a-c or d-c. Input values can be s low as 40 milliwatts. Temperature ange from −54° C to −100° C. Utilization f silicon controlled rectifier circuitry ermits performance of extremely high peed transfer functions while maintain-ng reliability in severe environments, hock, vibration and acceleration.
Circle 130 on Reader Service Card

New Literature

Sigmund Cohn Corp. has issued a 4-page bulletin describing their B3 Exothermic Pyrofuze Wire which, when heated to about 650° C, ignites with explosive violence and reaches a temperature of about 2000° C. Illustrated in the folder is a photograph of the wire showing actual explosion taken 50 milliseconds after ignition. Duration of exposure was 2 milliseconds. Further descriptive information and characteristics of the material are given in the bulletin.

Circle 165 on Reader Service Card

CFI Corporation (Ceramics For Industry) has issued Bulletin 958 describing their line of custom ceramic parts for industry. The company specializes in the integrated design and production of precision ceramics in the form of components, ceramic-to-metal seals, glass-to-metal seals, specialized compositions. Bulletin gives technical details on these and other products, as well as description of available services.

Circle 166 on Reader Service Card

Infrared Bulletin 11-010, a new 8-page brochure available from Barnes Engineering Company gives a comprehensive outline of the historical development and the scientific principles of 'black body' infrared radiators. It covers fundamental theory, the various radiation laws, and the curves and equations evolved by the major classical scientific contributors to the field. The bulletin includes a discussion of present-day design considerations for laboratory standard sources, as applied in Barnes OptiTherm (trademark) instruments, and detailed descriptions, photos and specifications are given for their complete line of infrared sources.

Circle 167 on Reader Service Card

Technical Bulletin #A-309, listing and describing standard Type A dessicant dryers is available upon request from Trinity Equipment Corporation. The bulletin lists sizing information, as well as operational and mechanical specifications on the wide range of Type A dryers available from the company.

Circle 168 on Reader Service Card

Allied Radio Corporation announces the release of its 1961 catalog of electronic equipment. Special emphasis has been placed on electronic equipment for industry. The new 576-page catalog lists over 48,000 items and includes 240 pages in rotogravure. It includes extensive listings of parts and equipment for industrial maintenance, research, and production requirements.

Circle 170 on Reader Service Card

Weldmatic Division Unitek Corp. has published the first issue of its new 8-page magazine; ELECTRONIC WELDING. Issued quarterly, it will provide the electrical, electronic and metal-working industries with authoritative, up-to-date information on precision metal-joining applications, such as assembly of electronic packaging, fine wire leads, thin and hard foils and screens, and miniature circuit modules.

Circle 171 on Reader Service Card

A new 32 page Safety Enclosure Catalog has been released by the Kewaunee Scientific Equipment Division of Kewaunee Manufacturing Company. It illustrates and describes their line of glove, vacuum and dry boxes; and controlled atmosphere systems for research and production purposes. Several pages are also devoted to illustrations of special enclosures and equipment made to a particular customer's requirement.

Circle 172 on Reader Service Card

Monsanto Chemical Company's Plastics Division has published a revised edition of a booklet describing the properties and typical end uses of its diversified line of plastic materials. The 12-page booklet includes detailed results of ASTM tests on the company's broad range of Lustrex styrene, Polyethylene and Opalon vinyl chloride molding compounds. It also features general information about the forms, typical uses and characteristics of Monsanto's fabricating, extruding, calendering and laminating materials; industrial, textile, surface and paper coating resins; adhesives and intermediates.

Circle 173 on Reader Service Card

Norton Company's new bulletin entitled "Mounting Sensing Elements" describes methods of mounting temperature and strain measuring elements by means of ROKIDE ceramic spray coatings. This technique is being used to mount such elements in areas subject to high temperatures, such as rocket nozzles, gas turbines, and nose cones, particularly in testing operations.

Circle 174 on Reader Service Card

"How to Clean Ultrasonically with Self Tuning," a bulletin prepared by Powertron Ultrasonics Corporation engineers, provides a basic explanation of how ultrasonics works, what it can do to provide the safest and most consistent cleaning performance, and a guide to selecting the correct tank and generator sizes or console model for the user's needs. A thorough chart-guide to the correct cleaning solutions and temperatures for more than 20 different common contaminants completes the bulletin, designated 60-1.

Circle 175 on Reader Service Card

Two transistor test instruments are described in a new 4-page brochure issued by The Hickok Electrical Instrument Company. Three pages are devoted to the new Model 870 Dynamic Beta Transistor Tester; complete specifications are given along with schematic diagrams showing the methods employed to measure *a-c* and *d-c* beta with the instrument. The fourth page describes Model 850P Portable Transistor Analyzer, with suggestions concerning its use as a breadboard in transistor research.

Circle 176 on Reader Service Card

A new Bulletin Sheet describing Penfield's latest Model M-100 Mono-Column Demineralizer has just been published The unit supplies up to 120 GPH of ultra high purity water with ion exchange action of top efficiency assured by a special control system that automatically keeps incoming flow constant. Complete specifications are given.

Circle 177 on Reader Service Card

SUBSCRIBE TO SEMICONDUCTOR PRODUCTS TODAY!

INDEX TO ADVERTISERS

For reference purposes, the advertisers index includes all regular advertisers who have run within the current contract year. Those advertisers who appear in this issue are indicated by the page number adjacent to their listing, and are shown in a bold-face type.

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